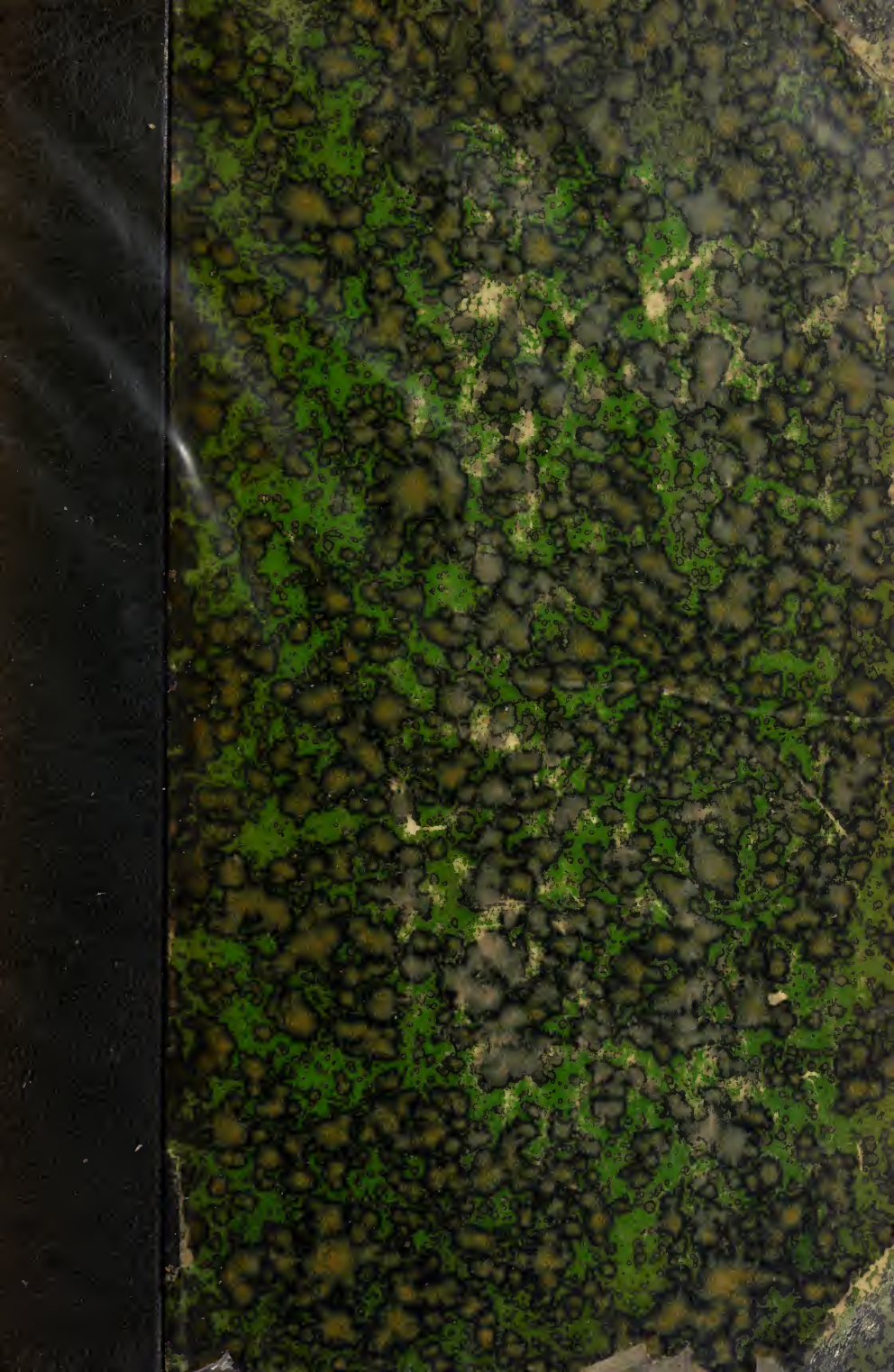




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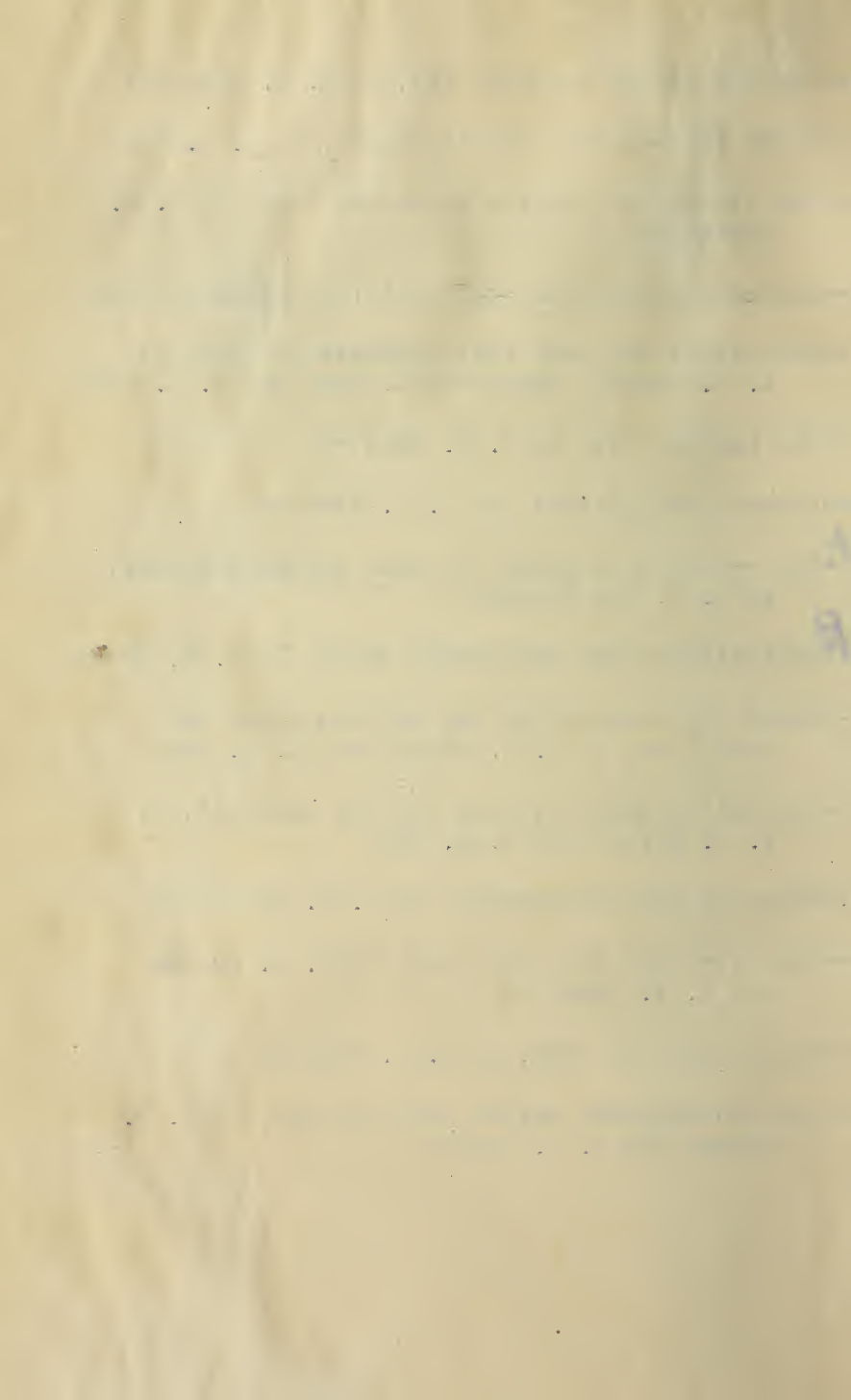
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IOWA AGRICULTURAL EXPERIMENT STATION

Farm Crops Division

Home-Made Seed Corn Testers

By H. D. HUGHES

The seed corn situation in the corn-belt states this year is serious. Not as much seed corn was saved last year as usual, and a large number of tests made in different sections of the state show this to be very low in vitality. Very little of it is fit to plant without first being carefully tested.

Most farmers who had seed for sale have already sold out their surplus, so the bulk of the corn planted this year on Iowa farms will have to be saved from the crop grown upon the farm the past season. The only way that ears from this crop fit for seed can be secured is by the use of the individual ear germination test.

VALUE OF INDIVIDUAL EAR TEST.

That the individual ear test is very effective and that it does show definitely the vitality of seed ears before they are planted was demonstrated in thorough experiments at the Iowa Agricultural Experiment Station in 1910 and 1911. More than 40,000 individual ear test readings were made with average good seed corn. Each year the planting of this corn bore out the tests. In 1910 the testing before planting increased the profits per acre 93.6 per cent and in 1911 85.7 per cent; it increased the yield 19.6 bushels per acre in 1910 and 10.1 bushels in 1911.

In comparing 6,139 readings in which the ears tested 6-0-0 (6 strong) with 1899, in which the ears tested 5-1-0 (5 strong, 1 weak), the planting of the ears in which but 1 of the 6 kernels tested was shown to be weak decreased the stand 6 per cent and the yield 3.4 bushels per acre. The planting of ears which had but 1 dead kernel out of the 6 tested, decreased the stand 10.8 per cent and the yield 6.2 bushels per acre.

HOME-MADE TESTERS EFFECTIVE.

In making the tests thirteen testers were compared, including most of those now offered on the market, as well as those which can be made at home.

It was fully demonstrated that the testers which can be made at home at little or no expense pick out ears for seed which will give as large yields as the ears picked out by the much advertised and expensive manufactured testers. Also, the manufactured testers have, on the average, thrown out as worthless 20 per cent more ears than the home-made testers, with a resultant loss for each acre planted of \$1.00 in seed corn. Some of the manufactured testers cause a good deal of valuable seed corn to be thrown away.

THE WATER METHOD.

Those testers, both home made and manufactured, which employ what is commonly known as the "water method," have usually thrown out as worthless a great many more ears than have the testers using sand, sawdust and cloth or blotters. The main advantage of the water method is its convenience and its cleanliness.

APR 3 1912

When labor is considered as worth 20 cents per hour, the cost of testing 100 ears has ranged from 15.6 to 45.3 cents. The cost with the Rag Doll was 18.2 cents and with the Sawdust Box 26.7 cents. It will be seen that from this standpoint the home-made testers must be considered very favorably.

A bulletin is now ready for publication giving full details of the two years' work in testing and planting seed corn and it will be ready for distribution soon.

DIRECTIONS FOR MAKING AND OPERATING HOME-MADE TESTERS

THE SAWDUST BOX TESTER



The Sawdust Box Tester with kernels in place.

Any box 3 or 4 inches deep and 30x30 inches in size may be used. Fill it about half full of moist sawdust well pressed down to an even surface. Before using the sawdust should be put in a sack and soaked in a tub of warm water for at least an hour (or still better, over night). On a piece of good white sheeting about the size of the box rule off $2\frac{1}{2}$ -inch squares in checker board fashion. Number the squares 1, 2, 3, and so on. Place it over the sawdust and tack to the inside of the box at the edges and corners.

Lay out the ears to be tested side by side or on a table where they may remain through the test without being disturbed. Remove 1 kernel from near the butt of ear No. 1, the middle and the tip. Turn the ear over and remove 3 more kernels from the opposite side in a like manner, taking 6 kernels in all and securing a sample from the entire ear. Place the 6 kernels at the end of the ear from which they were taken. Proceed in the same way with each ear and use care that the kernels do not get mixed. After the kernels are removed lay boards over the rows of corn to keep them in place until the germination is known.

Place the kernels from the ear No. 1 in square No. 1 of the germination box; from ear No. 2 in square No. 2, and so on with all the ears. Cut a good piece of cloth the size of the box and lay it on top of the kernels and dampen by sprinkling water over it. Then place over this a cloth about again as large as the box and fill in on top of this with about two inches of moist sawdust and press down firmly. Finally fold the edge of this cloth over the sawdust to cover it. Next set the box in a warm place where it will not freeze.

The kernels will germinate in about 6 days. Then remove the cover carefully to avoid misplacing the kernels in the squares. Examine the kernels. If one or more kernels in any square are dead or if some of the kernels are decidedly weaker than others, throw away the ear from which they came.

SPECIAL THINGS TO BE OBSERVED.

Be sure to soak the sawdust at least one hour, or better still, over night.

Use good quality of sheeting for the cloth that is marked off in squares and the cloth which is laid over the kernels.

Leave at least 2 inches margin between the squares in the box to prevent freezing and drying.

Never use the box a second time without first thoroughly scalding both the cloth and the sawdust. Take out both the cloth and the sawdust to do this.

Do not open too soon. The best reading may be made when the stem sprouts are about 2 inches long.

Throw out all ears showing injured germination as well as the worthless ones.

THE RAG DOLL TESTER



The Rag Doll Tester and Rolls.

One of the cheapest as well as most convenient and accurate methods of testing seed corn is known as the "Rag Doll" method.

For this test buy a few yards of sheeting of good quality and tear it into strips 8 inches wide and from 3 to 5 feet long. If it is planned to use the strips a number of times, hem the edges, as otherwise the ravelings sometimes disarrange the kernels in unrolling.

Down the middle of each cloth strip, lengthwise, draw a line with a heavy pencil. Then draw cross lines at right angles to the first to divide the strip into squares about 3 inches wide, as shown in the accompanying illustration. Number the squares, as shown in the illustration, also.

Wet one of the strips thoroughly and stretch it out in front of the ears to be tested. Take 6 kernels from ear No. 1, as was described in the Sawdust test, and place in square No. 1; take 6 kernels from ear No. 2 and place in square No. 2, and so on.

When the cloth has been filled, begin at either end and roll the cloth up. If the cloth is well moistened the kernels will not push out of place. When the cloth has been rolled, tie a string around each end rather loosely, or better still, use a rubber band. Number this roll No. 1. Then proceed with roll No. 2 in the same way. As many rolls may be used as are necessary to contain the corn which one has to test. From 30 to 50 ears can be tested in each roll, depending upon the length.

After the rolls have been filled they should be placed in a bucket or tub of water where they may remain from 2 to 18 hours, depending upon the preference of the operator. At the end of this time pour off the water and turn the bucket or tub upside down over the rolls, or use a common dry goods box for this purpose. A couple of small pieces of wood should be laid under the rolls and one edge of the pail should be lifted from $\frac{1}{2}$ to 1 inch in order to give ventilation. At the end of 5 days the kernels should be ready to read.

Depending upon the arrangement of the ears, select, first, either roll No. 1 or the last roll filled. This cloth will be unrolled in front of the ears represented. Examine all kernels carefully, as in the Sawdust test. In all cases in which all 6 kernels are not strong in germination the ear should be thrown away.

Both of these methods are so simple and inexpensive, and the seed corn situation is so serious, that no farmer can afford to plant seed that has not been carefully tested.

ADVANTAGES OF THE RAG DOLL.

1. The cheapest tester which can be made.
2. Anyone can make the tester in a moment's time.
3. Corn may be placed in the tester and the test read approximately as quickly as any other tester.
4. If one wishes to use the "water" method, the construction of this tester is well adapted for this. If saturated atmosphere with moist cloth contact is desired, this may be secured by leaving the rolls in the water only long enough to become thoroughly moistened.
5. Less mould develops in this tester than any other.
6. May be disinfected for mould most easily.
7. Very compact, and can be moved from one place to another without difficulty.
8. All parts of the kernel, roots, shoots, etc., can be readily seen.
9. Gives an accurate test, as indicated by field results.

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Circular No. 2. (Second Edition)

April, 1913

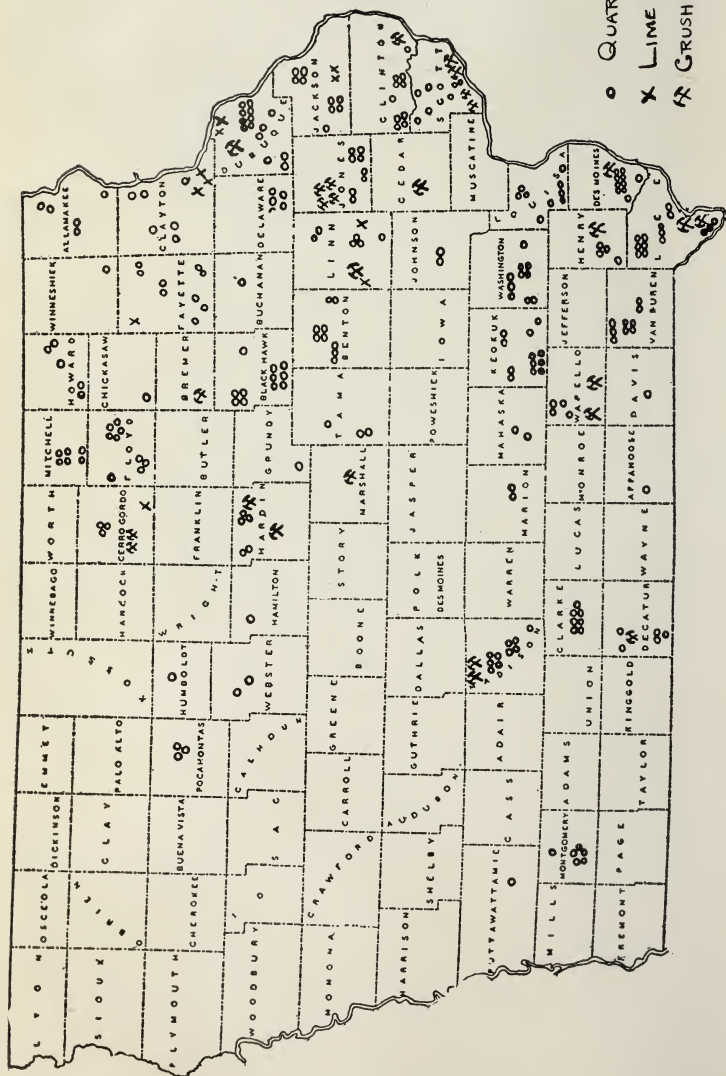
LIMING IOWA SOILS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Agronomy Section



Ames. Iowa



Map showing location of Lime Stone Quarries, Lime Kilns and Crusher Plants in Iowa

LIMING IOWA SOILS

By P. E. BROWN

Iowa soils are by no means generally deficient in lime, yet there is a large interest in Iowa in the question of liming. The Iowa Agricultural Experiment Station is receiving a great many inquiries about the subject and farmers are quite generally anxious to know whether or not they may apply lime to their lands with profit.

That is so partly because the practice is being urged for the small areas of slightly acid soils that are found here and there in the state and partly because of the extensive work in other states to restore fertility to soils that are seriously short of lime.

It is not hard to find out whether a particular soil needs liming.

In the first place, any farmer who wants to know the condition of his land may send a sample of its soil to the soils laboratories of the Iowa Agricultural Experiment station and have it examined free of charge. The station experts will not only tell him whether he ought to apply lime or not, but also answer other questions regarding fertilizing, cropping, etc.

But acid soils bear certain outward signs which the farmer may easily read and determine for himself whether or not his soil needs liming. For example, if crops of timothy or clover fail to grow properly and red top and sorrel make their appearance, the soil is usually in need of lime. Furthermore, the presence of moss or the growth of bluets, horse tails, and similar weeds, is evidence of a scarcity of lime in the soil.

There is a still more definite test for soil acidity which may be made on the farms—the litmus paper test, based on the power of acids to turn blue litmus paper red. If the blue litmus paper turns red when it is used to test the soil by this method, then the soil is acid. To make the test, secure a small sample of soil free from roots and grass and put it in some clear glass receptacle like a water glass. Insert two strips of blue litmus paper in the soil so that they are half covered. Then add pure water very carefully until the soil is thoroughly saturated. After the test has stood for several minutes the paper is removed and rinsed thoroughly. If the portion of it which was in contact with the soil has become red then the soil is acid and would be benefited by liming. The litmus paper may be bought at almost any drug store.

THE SITUATION IN IOWA.

But whatever may be found to be the facts as to individual farms here and there in Iowa, the soils of Iowa in general are by no means comparable with those of the eastern states or even with those of southern Illinois where large areas are strongly acid and applications of lime are absolutely necessary for the growth of profitable crops. It is extremely unlikely that Iowa soils will ever reach a similar state of infertility, but of course, proper methods of farming must be practiced to prevent such a catastrophe.

Most Iowa soils contain moderately large amounts of lime, the loess soils showing greater quantities than the drift soils, but there is great variation in soils of the same origin and type, and in many sections, particularly in the drift areas, the lime content is probably becoming rather low. As will be pointed out later, there is a constant removal

of lime from all cultivated soils, and consequently even although the normal lime content may be rather large, there is great danger of soils becoming deficient in lime, more or less rapidly, depending on various conditions.

Thus, while the question of liming in this state has not the importance attached to it that it has in many other states, there is evidence that more attention should be given to maintaining a proper reaction in the soil. Even although medium yields are being obtained, applications of lime may increase crop production and also lessen the rapidity of the loss of fertility.

It must not be understood from these statements, however, that lime alone will keep a soil fertile. Such is far from being the case. The rotation of crops, the application of barnyard manure or of green manure, the growth of legumes, proper methods of treatment, etc., should all be practiced and when that is done, applications of lime will play an important part in maintaining the soil in a fertile state.

THE BENEFICIAL EFFECTS OF LIMING.

The use of lime in agriculture is an exceedingly old practice and was prevalent many years before the cause of its beneficial action was even dreamed of. The investigations of the early agricultural chemists and physicists, and more recently of the soil bacteriologists, have shown that the action of lime on soils may be three-fold in nature.

CHEMICAL.

In the first place, lime may bring about or alter certain chemical reactions in the soil. Perhaps its main chemical value lies in its neutralizing action. Various organic substances are produced in the growth of plants and in the decay of plant remains and if they accumulate to any extent, they exert a decidedly depressing effect on crop production. Lime neutralizes these various substances and thus improves the "sour" condition of the soil. Lime also acts chemically as an indirect potassic or phosphatic fertilizer. By reacting with insoluble, unavailable compounds of potassium or phosphorous, assimilable compounds are produced in a state ready for plant food; thus complex silicates may be changed into soluble potassium carbonate, or unavailable iron, or aluminum phosphate may be changed into assimilable calcium phosphate.

PHYSICAL.

The physical effects of liming are quite diverse, depending on the character of the soil involved. On heavy, clayey soils, lime causes a flocculation of the fine particles and thereby materially improves the tilth, increasing the aeration and facilitating the circulation of water. On light, sandy soils, on the other hand, the addition of lime reduces its porosity, makes it more compact and consequently more retentive of moisture and subject to less intense oxidative processes which cause a depletion in organic matter. In both cases these changes lead to increased bacterial activities with consequently greater plant food production and subsequently to greater yields.

BACTERIOLOGICAL.

Bacteria are the active agents which bring about the transformation of insoluble compounds in the soil into soluble, assimilable, forms. Various groups of organisms are involved in the different processes. In the first place, and of perhaps the greatest importance in most soils, there occurs the transformation of complex animal and

plant remains into nitrates. The process of ammonification which constitutes the first stage in this simplification leads, as the term indicates, to the production of ammonia. Ammonia never accumulates in the soil to any extent but is transformed into nitrates by the nitrifying bacteria almost as rapidly as it is produced, the process being known as nitrification. The action of lime in increasing the extent, both of ammonification and of nitrification, is well proven. In the case of the latter process, the presence of lime is absolutely essential for its continuance.

Increased bacterial activities in the soil lead to the production of greater amounts of carbon dioxide, and this passing into solution in the soil water attacks the insoluble potassium and phosphorus compounds in the soil and renders them soluble. Thus, by encouraging various bacterial activities, lime may increase materially the supply, not only of nitrates, but also of available potassium and phosphorus in the soil.

There are other important groups of soil bacteria which are materially affected by the reaction of the soil. The organisms which utilize the nitrogen of the atmosphere, fixing it in the soil, and which are known as azotobacter, refuse to grow in acid soils and the addition of lime may lead to a large increase in the nitrogen content of the soils.

The bacteria which live in the nodules on the roots of legumes and by whose aid these plants are able to take the nitrogen from the atmosphere and utilize it in building up their tissues are rendered weak and useless by the absence of lime and the well-known beneficial effects of lime on leguminous crops are therefore not due entirely to the improved chemical and physical condition of the soil but also to the effect on the bacteria which bring about the inoculation of the plants.

It is evident from the facts just discussed that the presence of lime is essential for the best possible crop production in so far as it makes the soil more favorable chemically, physically and bacteriologically for the growth of plants.

LIME AND CROP PRODUCTION.

As has been stated, most Iowa soils contain moderately large amounts of lime, in many cases enough to keep them in a fertile condition. But if in some instances the lime content has decreased below a certain per cent, then the crop producing power of such soils will be low and the yields will be smaller than they should be. Of course, different crops are differently affected by the absence of lime; alfalfa, clover and other legumes are the most sensitive to such a deficiency, while potatoes, rye, oats and barley continue to give profitable yields when very little lime is present.

LOSSES OF LIME FROM THE SOIL.

There are two factors which bring about a depletion of the lime content of soils. In the first place, the removal of crops carries away quite large amounts of it; one ton of alfalfa hay, for example, will remove about fifty pounds of lime, and since a good stand of alfalfa may be maintained six to seven years and will average four to six tons per acre per year, the depletion of the lime in a soil by an alfalfa crop is very great. A large supply of lime in the soil will evidently be necessary to obtain a satisfactory yield of alfalfa. Other crops do not remove nearly as large amounts of lime as does alfalfa, but the losses, nevertheless, are quite appreciable and even although certain agencies are at work restoring small amounts to the soil, it is evident that the continuous cropping of a soil would eventually remove all the lime present.

The removal of lime by drainage water is very much greater and of more importance than the removal by plants. Soluble calcium bicarbonate is produced through the action of carbon dioxide on calcium carbonate and this bicarbonate may be leached out of the soil. The loss of lime by this means has been estimated as equivalent to 100 to 1,000 pounds of carbonate of lime per acre annually.

In ordinary farm practice, therefore, considerable lime is removed by these two means just discussed, and unless the soil is naturally very rich in lime, applications of it in some form will be necessary together with the usual treatment and fertilization in order to keep the crop producing power of the soil at the highest point possible.

THE CLASSES OF LIME.

Two classes of lime, quite different in character, may be employed for soil improvement. There are first the natural forms such as limestone, marl, shells, marble, etc.; and second, caustic lime, which may be used freshly burned, or in the hydrated form as slaked lime or as air-slaked lime.

THE KIND OF LIME TO USE.

The use of caustic lime has been very generally recommended because of the fact that more lime (CaO) is obtainable from a certain weight of caustic lime than can be obtained from the same weight of limestone (CaCO_3). In fact, if the materials were chemically pure, one hundred pounds of CaCO_3 would be equivalent to only fifty-six pounds of quicklime. The advantage, therefore, of this latter material is dependent largely on the difference in bulk, with the consequently cheaper freight rates per pound of actual lime. When the material must be transported for long distances, the difference here may be quite considerable. It is possible that under particular conditions it would be cheaper for the farmer to purchase quicklime than to buy the cheaper, more bulky limestone and pay the freight charges.

In general, however, in this state there is no question but that ground limestone or fine limestone screenings are more easily and more cheaply obtainable. Furthermore, there are certain objections to the use of caustic lime which have been pointed out from time to time. Although it is acknowledged that in most cases crop yields are increased more quickly by the use of caustic lime than by limestone, the action of the former is mainly as a soil stimulant and the soil may be left in a poorer condition than before the treatment. There occurs a too rapid destruction of the organic matter with a consequent over-production of available plant food and a loss of valuable humus and other constituents is occasioned. On soils very rich in organic matter, such as swampy or peaty soils, the use of hydrated lime in their reclamation would probably be advisable, but under ordinary soil conditions ground limestone will yield just as satisfactory results and there is absolutely no danger of adding too much and thus injuring the crop and causing a serious depletion in the organic matter. In the case of legumes it has been shown by many experiments that, if it is easily obtainable, ground limestone is better and cheaper than caustic lime.

In general, therefore, it may be said that ground limestone or fine limestone screenings, seems the logical material to be used by Iowa farmers for remedying acid conditions in their soils.

It has usually been believed that when ground limestone is applied to a soil, the finer the state of division of the particles the better will be the results, but of late the idea has become prevalent that limestone may be in too fine a state of division and there may be too rapid a loss

of the material. The statement has been made that a ground limestone or screenings composed partly of powder and partly of coarse particles will give better results and persist longer in the soil than a material composed entirely of fine particles. In general it may be said that limestone should consist of at least 60 to 70 per cent powder to be of the most value.

There are both magnesian and non-magnesian limestones in Iowa. That is, there are those which consist mainly of magnesium carbonate (MgCO_3) and those which contain mostly calcium carbonate (CaCO_3). These two carbonates act very similarly in the soil and while it has been claimed that one may be more beneficial on certain soils than the other, no definite statement can be made for particular soil conditions in Iowa.

We believe that the ease of obtaining the limestone and its cost should govern in its choice rather than the content of lime or magnesia in it.

THE METHOD OF APPLYING LIMESTONE.

The application of limestone to a soil should be made after plowing and it should then be thoroughly disced or harrowed in. It is not advisable to apply before plowing, as lime tends to move downward in the soil, and the full benefits from the application may not be obtained if the material is not thoroughly incorporated with the surface soil.

The uniform distribution of the limestone may be accomplished by the use of a regular lime spreader such as is now being made by manufacturers of grain drills. Sometimes it is applied by means of a manure spreader, but with little satisfaction, and often it is spread by hand with a shovel either from the wagon or from piles of the limestone placed at equal intervals over the field.

The amount of ground limestone which should be applied to a soil will depend, of course, on the acidity and general character of the soil, and also on the crop which is to be grown. For grain and grass crops, an application of 2,000 to 3,000 pounds of lime per acre every fourth season would probably be sufficient, while where alfalfa, clover, and other legumes are to be grown, 3,000 to 4,000 pounds per acre should be used once in the rotation. Of course, there will be exceptions to this rule and soils which show a distinctly acid reaction by the litmus test should receive applications of 4,000 to 6,000 pounds or even larger quantities per acre.

WHERE LIMESTONE MAY BE OBTAINED.

There are several firms in Iowa which are prepared to furnish limestone for agricultural purposes, and among them may be noted the following:

McManus & Tucker, Keokuk, Iowa: Will furnish a material composed of fine particles down to dust and consisting of sixty (60) per cent dust, at 50 cents per ton, F. O. B. their quarry.

The Ellsworth Stone Company, Iowa Falls, Iowa: Offer screenings consisting of sixty (60) per cent dust at \$5 per carload of thirty tons, F. O. B. their quarry.

The Peru Stone & Cement Company, East Peru, Iowa: Offer material similar to above, free of charge for carload lots, *during 1913*. If less than carload lots are purchased, they charge 20 cents per cwt. to cover the cost of bagging, etc.

Dolese Bros. Co., at 1310 Otis Building, Chicago, Illinois, with quarries at Buffalo, Iowa: Offer a limestone consisting of 92.68 per cent CaCO_3 and in a fine state of division, at 25 cents per ton, F. O. B. cars, their quarry, Buffalo, Iowa.

The Fort Dodge Portland Cement Corporation, Gilmore City, Iowa: Offer a very fine, pure limestone at 50 cents per ton, F. O. B. their quarry.

The Burlington Quarry Co., 19 S. 7th St., Keokuk, Iowa, with quarries at Montrose, Iowa: Prepared to furnish a limestone at 25 cents per ton, F. O. B. their quarry.

J. A. Green & Sons, Stone City, Iowa: Will furnish a material consisting of sixty to seventy-five (60-75) per cent dust, at 50 cents per ton, F. O. B. their quarry.

H. Dearborn's Sons, Stone City, Iowa: Offer limestone composed of fifty (50) per cent dust at 15 cents per ton, F. O. B. their quarry.

F. Erickson & Company, Stone City, Iowa: Will furnish a material containing twenty-five (25) per cent dust at 25 cents per ton, F. O. B. their quarry.

The Linwood Quarries Co., Davenport, Iowa: Offer limestone screenings from the size of a pea down to dust at 25 cents per ton, F. O. B. their quarry.

Bartlett & McFarland, Waterloo, Iowa: Will furnish a limestone at 50 cents per ton, F. O. B. their quarry.

B. N. Arquitt & Sons, Farley, Iowa: Will supply a material at 80 cents per ton.

Charles Chilton, Ottumwa, Iowa: Will furnish material at 75 cents per ton.

John Boland, Bettendorf, Iowa: Will furnish limestone at \$1.15 per ton, F. O. B. their quarry.

John Rowen, Stone City, Iowa: Will supply material ranging from fine dust to one-eighth inch in size at 25 cents per ton, F. O. B. quarry.

There may be other concerns in the state which are prepared to supply the demand for agricultural lime in their immediate locality, but the above constitutes the complete list of those who replied to a circular letter which was sent out from the Iowa Agricultural Experiment Station, to ascertain the sources from which limestone suitable for application to the soil might be obtained.

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Circular No. 4

September, 1912

GOOD SEED CORN FOR 1913

WHY SEED HAS BEEN POOR
REMEDY USUALLY SUGGESTED
CONDITIONS IN 1912
INSURE GOOD SEED FOR 1913 NOW
SEED MUST BE PICKED EARLY
SELECT SEED IN THE FIELD
USE CARE IN DRYING THE SEED
GIVE GOOD VENTILATION AND DRY AIR
GOOD PLACES TO STORE SEED
METHODS OF STORING

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

AGRONOMY SECTION

Farm Crops

AMES, IOWA

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GOOD SEED CORN FOR 1913

BY H. D. HUGHES

Whether Iowa farmers will have good seed corn for next spring's planting will depend upon whether they select their seed in the field early, before a sharp freeze, and whether they dry it properly this fall and store it in the right kind of a place this winter. If any one of these factors is neglected, the man who neglects them is more than likely to be without good seed corn in 1913.

Although a general alarm about seed corn has been sounded regularly every fall for some years, the vitality of the seed in the spring has become worse rather than better. This is true, not because of the greater attention given to the selection and care of seed in the fall, but rather in spite of it.

WHY SEED HAS BEEN POOR.

The low vitality of seed in recent seasons has been due, first of all, to the fact that Iowa farmers are growing very much larger, later maturing varieties than formerly. This later maturing corn contains considerably more moisture when harvested than Iowa seed corn formerly did. The water content often ranges as high as 60 per cent at the time of picking seed whereas the moisture found in well-cured corn is from 10 to 14 per cent. These later maturing varieties are also deeperkerneled and have considerably less space between the rows, making it even more difficult to get rid of this large excess of moisture before freezing weather comes on.

The second cause for low vitality is what may be termed exceptional, unfavorable weather in the fall. Under such unfavorable conditions, which occur every year, sometimes in one locality and sometimes in another, the earlier maturing types of corn which were formerly grown showed little injury. This, together with the fact that many falls are long and dry, led to the habit of waiting until October or November to select seed corn. This delay in saving seed may be called still another cause for the conditions referred to.

These several factors were very largely to blame for the very poor quality of seed corn in the seasons of 1910 and 1912.

THE REMEDY USUALLY SUGGESTED.

When these conditions are faced, the usual advice is to test separately the germination of each seed ear. While this is the best possible thing which can be done under the conditions, it cannot make up for carelessness and neglect in the fall. When seed is injured by freezing, the stand in the field will seldom range above 75 per cent, even when each ear is tested separately and when only those ears



Examining the Ears While on the Stalk.

are used for seed whose kernels when tested showed strong vitality. Seed which is perfect in vitality, having been selected early and carefully stored, should give at least 95 per cent of a stand, other conditions being favorable.

CONDITIONS IN 1912.

Because the Iowa Agricultural Experiment Station and the agricultural and newspaper press of the state had so many times called atten-

tion to the poor condition of a great deal of the seed corn, many farmers last spring paid scant attention to the facts presented. They assumed, apparently, that the members of the state experiment station staff and the newspapers had formed a habit and that they issued such warnings whether there was particular need or not. The result was that many men in every community did not come to realize the true condition of the seed supply until just before planting time. Then there was little or no opportunity to test out their own seed and then, also, it was quite impossible to buy seed of good vitality which was adapted to the local conditions because good seed was scarce everywhere. Consequently, in spite of the work of the station, the press, the railroads and other organizations, much corn was planted which was not up to the standard of good seed.

INSURE GOOD SEED FOR 1913 NOW.

What is done this fall and winter will determine very largely the quality of the seed corn next spring. Unless prompt measures are taken and great care is used in picking seed corn early this fall, and in drying it as quickly and as thoroughly as the conditions will permit, Iowa seed corn in the spring of 1913 will be of even poorer quality than that available in the spring of 1912. The summer of 1912 has been remarkably cool and as a result the corn has not matured as rapidly as in an average season. Most of the corn over the state is without doubt from ten days to two weeks late in maturity.

SEED MUST BE PICKED EARLY.

To insure good vitality the seed must be picked as soon as it is thoroughly well dented, and before there is danger of a sharp freeze. While it is possible to pick seed corn too early, before the vitality and vigor of the kernels have developed to the fullest extent, yet the selection should not be unduly delayed. The last week in September and the first week in October will probably be the most opportune time for selecting most of the seed corn. It will be possible to pick some corn before this date.

SELECT SEED IN THE FIELD.

There is but one logical place and method to select seed corn, and this is in the field, direct from the stalk, picking several times as much as will be required to plant the area proposed to be put in corn the next year.

In selecting corn in the field there are several things which must be taken into consideration:

First, select those ears which give indication that they will produce corn which will mature well in an average season. Maturity may be measured by the dryness of the leaves and husks and the indentation of the kernels.



A Good Hill from Which to Select Seed;
Three Good Strong Stalks, Each
Bearing a Good Ear.

Second, select ears only from hills which have three stalks. Careful tests indicate that good seed ears developed under these conditions will yield more and better corn than ears of as good or better appearance, grown in hills having fewer stalks and where the competition was consequently less severe.

Third, study the stalk producing the ear selected. It is now well known that by selection it is possible to control very largely the character of the stalk, its general strength and vigor, its height, the height at which the ear is borne and the position of the ear. Select ears from stalks which tend to be sturdy, rather than too tall, which have a medium to good development of leaf and on which the ear is borne at a convenient height and drooping rather than erect. Experiments indicate that ears borne high, rather than low, will give the greatest yields, but it is well to remember also that corn is inconvenient to husk when borne very high and that a greater per cent of these stalks will break over, with more corn damaged and lost as a result.

USE CARE IN DRYING THE SEED.

Early fall selection of seed is necessary, but this in itself will not insure

good vitality the following spring. Seed corn must also be properly dried and cured; it must be freed quickly of a large share of its ex-

cess moisture before freezing weather comes on, and it must have good ventilation to prevent mould or fermentation setting in. Otherwise the vitality is almost sure to be greatly impaired. That early selection alone is not enough has been shown repeatedly by the large amount of corn gathered in this way which is yet worthless the following spring. Proper care in drying the corn in the fall and in storing it in the winter is of the greatest importance.



Artificial Heat May Be Used to Get the Ears Dry Before Freezing Weather Comes On. Note that Good Ventilation is Assured, Yet that the Large Door Can Be Closed in Damp or Cold Weather.

GIVE GOOD VENTILATION AND DRY ATMOSPHERE.

In choosing a place to store seed corn, two factors of prime importance are to be considered.

First, ventilation.

Second, a dry atmosphere.

As already stated, the seed ear when taken from the field may contain in the neighborhood of 60 per cent of water, while to be safe

from freezing weather, corn should contain not much more than 10 per cent of moisture. This means that a very large amount of water must be thrown off, and this in a very few weeks.

It is especially important, therefore, to have good circulation of air around the seed corn to cure it properly. With a new supply of dry air coming continuously in contact with the seed ears, a large amount of water may be carried away in a comparatively short time. To get this result, provision must be made for thorough ventilation.

In the fall of the year there are usually a comparatively large number of days when the air is dry, but there are also times of misty, rainy weather when the air contains much moisture. During such wet "spells" all doors and windows must be closed as tightly as possible; otherwise the corn may absorb a great deal of new moisture, since after it is once dry it can absorb water almost as quickly as it can throw it off. It is important that the air coming in contact with the seed ears be dry.

PLACE TO STORE THE SEED.

On most Iowa farms only enough seed for home use is saved. Where this is the case, storage places must be found which fill all the requirements for good storage without making it necessary to provide a special building. On the larger farms or on farms where considerable seed is to be saved for sale, special storage buildings may be desirable.

A vacant or little used room in the house, which preferably has windows on at least two sides, is perhaps the best place for the seed ears as good ventilation is assured there in the fall and the room is likely to be warmer and dryer in the winter than most other places which might be used.

A good, dry cellar, with plenty of windows which may be opened for ventilation, has been found satisfactory because in such a place there will be little likelihood of the corn freezing. This is especially true if any kind of a furnace is used. However, unless thoroughly good ventilation is insured, the corn had better be hung in some building where doors and windows can be opened wide during drying days, but closed tight during damp weather. Before danger of a severe freeze the corn may be removed to the cellar. Since it is then more thoroughly cured than when brought from the field, it may also be corded up on racks, in this way requiring much less space than would otherwise be necessary.

The attic is usually dry, and may prove a good place for the seed provided it can be properly ventilated.

If the seed is to be stored in the barn or in some outbuilding, it must not be placed near stock or over a crib of corn or other grain.



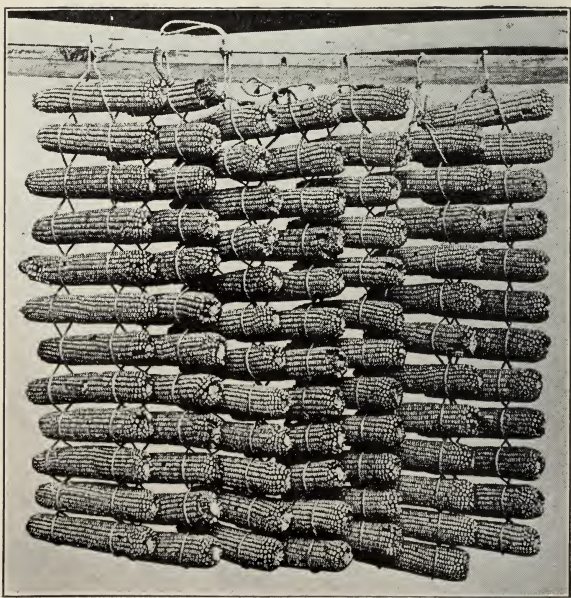
A Piece of Twine 15 Feet Long is a Convenient Length.



Holding the First Ear in Place with the Feet, the Strands are Crossed as Shown and the Second Ear Put in Position



Ready to Hang Up.



A Bushel of Corn in Good Condition to Dry and in Small Space.

Under such conditions there is usually considerable moisture in the air during the greater part of the winter, and this, combined with a hard freeze would likely prove disastrous to the vitality of the corn.

METHOD OF STORING.

The method of storing is of secondary importance provided the place is right. The method selected should, however, provide a free circulation of air on all sides of each ear. In other words, no two ears should touch nor should they lay flat upon a board or other surface. This is especially important when the ears are selected early and contain a large amount of moisture.

It is also important that the seed be protected from mice and rats. A method which probably best meets both of these conditions is that of hanging the seed from a wire pole, or rafter with binder twine as is shown in the accompanying illustrations. In this way a large amount of seed can be hung in a comparatively short time and in a little space.

Woven wire, tacked on both sides of a framework made preferably of 4" material, using care that the meshes are opposite, makes an excellent rack. Lath tacked 3 to 4 inches apart on each side of 4" up-rights make excellent, cheap racks, each pair of lath accommodating twenty-five or more ears. Such a rack 5 feet in height holds 400 ears. A device which is especially desirable for storage, because it makes the sorting and testing of the seed especially easy, is a tray made by sawing 1"x4" material into 4" lengths, using 3 of these and 2 lath to make a tray, nailing the lath on the ends of the 4" pieces at the lower edge. These strong, light trays can be conveniently piled one above another, forming racks. The cost of material sufficient to hold 100 ears is about 10 cents.

Other good devices are made by driving nails into boards, poles, posts, etc., over which the butts of the ears are thrust.

A large number of devices for storing corn have been offered on the market. Many of them give good satisfaction and may be used by those who do not care to devise a method of their own. Home-made methods may be used, however, with as great satisfaction.

Other bulletins on seed corn which are available, and which may be secured by writing to the Bulletin Editor, Iowa Experiment Station, Ames, Iowa, are:

Circular No. 1.

Extension Bulletin No. 9.

UNLAWFUL IOWA WEEDS AND THEIR EXTERMINATION

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Botany Section



Ames, - Iowa

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UNLAWFUL IOWA WEEDS AND THEIR EXTERMINATION

BY L. H. PAMMEL AND CHARLOTTE M. KING

The Iowa weed law is violated in many parts of the state, partly because the farmers and some officers are unfamiliar with the law, and partly because they are not interested in the important question of weed control.

The weeds recognized by the law as noxious are:

Quack grass, *Agropyron repens*.

Canada Thistle, *Cirsium arvense*.

Cocklebur, *Xanthium canadense*.

Wild Mustard, *Brassica arvensis*.

Curled Dock, *Rumex crispus*.

Smooth Dock, *Rumex altissimus*.

Buckhorn, *Plantago lanceolata*.

Wild Parsnip, *Pastinaca sativa*.

Horse Nettle, *Solanum carolinense*.

Velvet-weed, *Abutilon Theophrasti*.

Burdock, *Arctium Lappa*.

The Thirty-third General Assembly passed a law compelling the removal of certain weeds from the public highway, and from lands adjacent thereto, etc., as follows:

Section 1. Land Owners or Tenants to Destroy Weeds—When. It shall be the duty of every person, firm or corporation owning, occupying or controlling lands, town and city lots, land used as right of way, depot grounds or for other purposes to cut, burn or otherwise entirely destroy all weeds of the kinds mentioned in section two (2) hereof at such times in each year and in such manner as shall prevent the said weeds from blooming or coming to maturity."

THE LAW'S PENALTIES

The law provides also a method of procedure in case of neglect to remove noxious weeds from highways.

"Section 3. Destruction on Highways—Neglect or Refusal to Destroy. It shall be the duty of the township trustees or other officers responsible for the care of public highways in each township or county in this state to destroy or cause to be destroyed all noxious weeds mentioned in section two (2) hereof or unnecessary brush on the highways in such a manner as to effectually prevent the production of their seeds

or their propagation in any other manner, to warn out labor or to employ labor for this purpose in the same manner as for repairs to the highways, and for neglect or failure to perform this work they shall be subjected to the penalties in this act. If any occupant of lands adjacent to the public highways neglect or refuse to destroy the noxious weeds upon his land, or shall fail to prevent the said noxious weeds from blooming or coming to maturity, when such weeds are likely to be the means of infesting the public highway, or upon complaint of any land owner to the township trustees that his lands have been or are likely to be infested by weeds from the lands of another including railway right of way, the trustees shall make investigation of such condition or complaint and if the same appears to be well founded they shall make an order fixing the time within which the weeds shall be prevented from maturing seed, and an order that within one year such noxious weeds shall be permanently destroyed, and prescribing the manner of their destruction and shall forthwith give notice to the occupant of the lands where the noxious weeds exist, and if he shall neglect to obey such order within the time so ordered the trustees may cause such noxious weeds to be prevented from maturing seeds or may cause such noxious weeds to be permanently destroyed and the cost of the work shall be recovered from the owner by a special tax to be certified by the township clerk in the same manner as other road tax not paid."

GENERAL SUGGESTIONS ON THE EXTERMINATION OF WEEDS

Kinds of Weeds. Three general classes of weeds must be considered.

First, annual weeds, represented by foxtail. Their seeds germinate in the spring, flower, produce seeds and then die. Their roots are fibrous, and are usually easily killed by exposure to the sun in ordinary methods of cultivation. In some few cases, as in crabgrass, roots are produced from the joints where such weeds lie on the ground.

Second, biennial weeds. Their seeds germinate one season and produce a mat of leaves, pass through the winter, and the next season send up a stem which bears flowers and seeds, and then dies. Such weeds should be cut off several inches below the surface of the ground. This should be done the first season, or before the plant has produced seed. Never cut them off at the surface of the ground. If so treated they act like perennials. Weeds of this class are represented by burdock and parsnip.

Third, perennials. This class of weeds is represented by Canada thistle, quack grass, dock, and sheep sorrel. They continue to grow year after year.

GENERAL RULES TO BE OBSERVED

1. Prevent the Formation of Seeds. This applies to all kinds of weeds. Many seeds of weeds like foxtail, and other weeds of the grass family, do not retain their vitality very long. Some, however, like shoofly, velvet-leaf or butter print, retain their vitality for a long period of years. It is essential that no seeds be allowed to form because a continuous crop of weeds will appear when the soil is brought under cultivation.

2. Always Buy the Best Seed. See that such weed seeds as dodder, buckhorn, dock, Canada thistle, chicory, carrot, and other weeds are not sown with clover and other seeds.

3. Practice Rotation of Crops. Many weeds are found in special crops. In this rotation clover should occur, because a thickly grown clover crop crowds out weeds. A pasture, in many cases, is good to reduce the number of weeds.

4. Use Due Care with the Threshing Machine. See that the machine is always cleaned when passing from one farm to another. Quack grass, mustard seeds are often carried from one farm to another.

5. Use care in transplanting hay, grain, straw and manure from one farm to another, or from the city to the farm. Quack grass and other weeds are frequently carried in this way.

6. Utilize sheep for the destruction of weeds.

7. Use some vigorous and thick growing crop to crowd out weeds. For this purpose sorghum, clover, or millet is good.

8. Give thorough and clean cultivation for corn. Cultivate as long as the corn crop will permit.

9. As far as possible plow small grain crops and corn fields in the fall. This will destroy many annuals whose seeds germinate in the fall; especially valuable for winter annuals like shepherd's purse and peppergrass.

10. Use iron sulphate for annual weeds like mustard, ragweed, and smartweed.

11. See that all weeds in waste places are removed. This will prevent their spread to cultivated fields.

QUACK GRASS

This weed is also known as quitch or quick grass but the Iowa farmers know it generally by the name of quack grass. It is a bright green, rarely glaucous green, perennial, spreading by means of its



Quack grass.

Agropyron repens.

underground rootstocks commonly called "roots"; the sheaths are generally smooth though occasionally somewhat hairy; leaves slightly less roughened than the western wheat grass, which although much like quack grass has glaucous green leaves which are very rough on the margin. The flowers are borne in "heads" which vary in length from a few inches to ten inches. Each separate part of the "head" is called a spikelet which is about 5-flowered; "chaff" $\frac{3}{10}$ to $\frac{4}{10}$ inches in length, acuminate or awn pointed, smooth or more or less scabrous, the lower of the scales (lemmas) inclosing the seed, the outer, strongly nerved, terminating in an awn. The rootstocks are yellowish straw-colored or greenish yellow; in ordinary cultivated soil in Iowa usually found from the surface soil to a depth of four inches, or occasionally to a depth of six or seven inches; in meadow two and three inches below the surface.

Western wheat grass in its habits of growth, rootstocks and head, resembles quack grass, but may readily be distinguished by its thicker heads, larger spikelets, and scabrous leaves which are decidedly bluish in color. It is not as difficult to exterminate as quack grass.

This grass is very common along railroads which have largely been responsible for its spread in Iowa. This grass is very nutritious and is a most desirable grass for sandy soil and places subject to washing.

Various methods have been given for the extermination of quack grass. The following methods have been found effective: sorghum method, summer fallow, pasture and meadow land and tarred paper method; of these the sorghum method is the most effective.

Summer Fallow.—The summer fallow method has been tried to a limited extent in Northern Iowa. The land is plowed in the spring, disked and harrowed at least once each week during the entire season; the frequent cultivation brings the roots to the surface and the direct

sun destroys them. This method means a loss of the crop and is not to be recommended for expensive Iowa meadow and pasture land. When meadow or pasture has been down for several years the root-stocks are found much closer to the surface of the ground than in cultivated fields. In order to destroy quack grass the sod can be cut to a depth of about three inches. Mr. Cates recommends for this purpose a Scotch-bottom plow which has a very long, gradually sloping moldboard. With this type of plow the sod can be given very shallow cultivation. In a week the disk should be used. When the disking is thoroughly done repeat the operation in a week or ten days continuing this during the dry weather of the fall. This will probably kill a vast majority of quack grass roots. Where this method has been tried it has been found very good, leaving the soil ready for a crop the next season.

Tarred Paper Method.—Tarred paper method is advisable where there is only a small patch of quack grass. In laying down the tarred paper the edges should be over-lapped carefully to exclude light. One should be careful also to let the tarred paper extend some distance beyond the quack grass as the quack grass roots are sometimes three feet long. Six weeks of hot weather will kill them out. In this connection it may be well to state that a covering of straw or manure is frequently used in bringing the roots to the surface where there has been shallow cultivation, the roots then being destroyed.

Sorghum Method.—When this method is used, especially where the quack grass has been in small grain, the infested ground should be given a shallow plowing as soon as the oats, wheat, or barley has been cut. Plow shallow and disk exposing the roots to the sun. As soon as the quack grass comes through the ground harrow the field; repeat this as often as may be necessary through the months of August and September as these months are frequently dry. This will help to destroy a large number of roots for the next season. The next season, when the soil is in good condition, sow sorghum at the rate of $1\frac{1}{2}$ to 2 bushels per acre. The sorghum will crowd out the quack grass. This method has been tried successfully both on the College Farm, and elsewhere in the state. There is no other method as good as this.

In some cases it has been found advisable where the "roots" are abundant in the field to rake them up and burn them. An absolutely clean culture throughout the entire season, while preventing the growth of leaves which make the food of the plant to be stored in the roots, while effective, is rather an expensive method.

CANADA THISTLE

The Canada thistle can be treated with the sodium arsenite. No other chemicals, so far as our experiments extend, will entirely destroy this weed. Carbolic acid only partially destroys the roots and the plants shoot up again from below the point of injury, but by repeating the process the Canada thistle can ultimately be exter-

minated. A good method to eradicate the weed is to plow shallow and cultivate frequently during the summer. The roots of the Canada

thistle extend deeply down into the soil, hence for this reason deep cultivation will be of no avail. After plowing, the soil should be dragged and the roots exposed to the sun and removed, when possible. It may be necessary to run over the field with a hoe to cut off the stray plants which appear. This method was tried on a patch several years ago and no Canada thistles have since made their appearance in this place. Various crops, such as clover and sorghum, are said to be effective in subduing the thistles.

Of the various chemicals which have been used to exterminate Canada thistles none is more effective than sodium arsenite. It is ap-



Canada Thistle.

plied at the rate of one and one half to two pounds to 52 gallons of water. This will destroy all vegetation. It is very poisonous and stock should not be allowed upon areas treated with it for a long time.

Carbolic acid at the rate of one part to one part water destroys the root where it comes in contact with the mixture, and for a little distance beyond. This is not an effective method, as the roots sprout out from below. Use due care in handling carbolic acid.

In response to circulars of inquiry sent out by the Iowa Experiment Station, the majority of correspondents recommended shallow plowing, disking, and harrowing; and continuing cultivation and hoeing as long as the thistles make their appearance. Some report successful treatment with salt when scattered thickly about the thistles, especially

if cattle or sheep are given access to it. Some report success with carbolic acid where it is applied directly to the stem. Tarred paper in a few instances gave success, as did also the method where the thistle was covered thickly with straw or manure. The depth of covering was not, however, given.

COCKLEBUR

The cocklebur is a serious menace to cultivated crops in many parts of the state, more especially in southern Iowa. A large number of queries sent out to farmers in different parts of the state brought many responses. Nearly every correspondent reported the weed. The seed habit of cocklebur differs materially from that of many annual weeds that belong to the same family. The bur has two so-called seeds, one of which has a slightly different position from the other;

the seed coat, too, is slightly different in structure and, according to Dr. Crocker, this is the reason for delayed germination. Dr. Arthur in a study of the seeds, determined that the opinion generally prevailing, that one seed will germinate one season and the other the following, is essentially correct. We have found in our own work that occasionally both seeds germinate the same season. It is very plain, therefore, that if cocklebur occurs in the soil you can not hope to destroy more than about one half of the seeds in one season, and if the same field is cultivated with corn the next year, another crop of seedlings will come on. How long the seeds will retain their vitality has not been definitely



Cocklebur.
Xanthium canadense.

determined. The best method of combating the cocklebur is the rotation of crops and clean culture. When a field is in corn, the field should be thoroughly cultivated and none of the plants allowed to mature seed. If they can not be caught by the cultivator, it may pay to kill the remaining plants with a hoe, or to pull them by hand. The corn should be followed with winter rye and then oats, using the oats as a nurse crop for clover and timothy. Leave the field in meadow for at least two years and then if possible turn it into pasture. This certainly eradicates the cocklebur, ragweed and many other annual weeds.

MUSTARD



The first and most important consideration in connection with the extermination of mustard is that the oats or wheat should be freed from mustard seed. Then this grain should be sown on clean fields, preferably fields that have been in pasture or meadow. Nothing has done so much to remove the weeds from the fields of northern Iowa as the pasture and meadow. If the grain is sown in a corn field there should have been no mustard the previous season. Having sown the small grain on a clean field there is always a chance that some of the seeds will retain their vitality in the soil. If much of this should come up it may become necessary to spray it with iron sulfate. Where the mustard is abundant this is a very effective means of destroying the weeds, using the sulfate at the rate of one hundred pounds to a barrel of water.

MILKWEED

Milkweed, like the morning-glory, is a deep-rooted perennial and where abundant in small grain fields it is rather difficult to remove. The plowing here should always be shallow, as the roots are deep seated and new plants spring up from where the roots are cut off. The plowing should be followed by disking and harrowing to expose as many of the roots as possible and the field should be turned into pasture as soon as possible. It is seldom that milkweed becomes injurious to pastures as the plants lose their vitality. It is by continuous

cropping with one crop that the weed becomes pernicious in its character.

In response to a query sent out one correspondent recommended oats one year, clover one year, corn two years, saying the weed is not troublesome in the pasture after the second year. Some have advocated pulling the weed by hand. This is not practical.

THE DOCKS

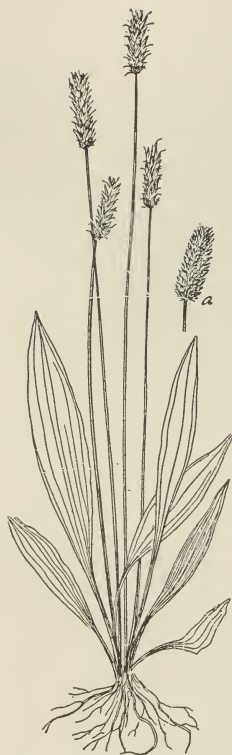
Description.—The sour or curled dock, and the pale dock are at times troublesome as weeds. Curled dock is a smooth perennial from

three to four feet high, leaves with strongly wavy and curled margins, lanceolate and acute. The lower leaves inclined to be heart-shaped at the base. The flowers are arranged in dense whorls prolonged into racemes, leafless above but with small leaves below. The fruit is brown, and three-angled. The pale dock occurs in low ground, and is from two to six feet high. The leaves are pale in color, longer than in the curled dock, and the edges are not wavy. The long, spike-like panicles are nearly leafless. Both species have become common in the state. They are perennial weeds; curled dock may be easily rooted out by hand when the soil is wet. When very abundant it is sometimes well to use the spud or to blow.



Curled Dock.
Rumex crispus.

BUCKHORN OR RIBGRASS



Ribgrass or Buckhorn.
Plantago lanceolata.

This weed was widely scattered in this state prior to the passage of the Iowa seed law, and probably will be found in many different counties. It is extremely common in the east. This weed is a perennial, or possibly in some cases a biennial, with a short root-stock and numerous narrow, lance-shaped leaves, with brownish hairs at the base. These leaves usually form a rosette. The flower-stocks are at first short. The head looks something like the head of timothy, having at first a yellowish color due to the anthers of the stamens. The seeds are chestnut-brown, polished, with a groove on one side. It flowers during the entire season, from May until frost. In England the plant is used to some extent for forage purposes, but its quality is not very high.

Sow clean seed in clean soil and there will not be very much danger from this weed. We would recommend that a clover meadow badly infested with it be turned under before the seeds have matured, soon after the first crop of clover hay is cut. Then follow with a corn crop. There is no practical way of separating rib-grass seed from clover seed. Clover seed containing ribgrass is, therefore, difficult to sell and will not bring the price of seed free from this weed.

WILD PARSNIP

This plant has become a common weed about meadows and gardens. It is a tall plant, with thick grooved stem, long, cut-toothed leaflets, a wide spreading umbel of yellow flowers and a deep root which has poisonous properties according to some authorities.

The wild parsnip is one of the biennials, and may be killed by deep cutting either in the fall or before the plants bloom in the spring.



Wild parsnip.
Pastinaca sativa.

HORSE NETTLE



Horse Nettle.
Solanum carolinense.

In southern Iowa the horse nettle is one of the most troublesome weeds to deal with. Like morning-glory and milkweed it is a deep rooted perennial. The roots are known to extend into the soil as much as three to four feet. The cultivation here should be shallow. When the weed is common, disk thoroughly and harrow, exposing the roots. When a field is covered with it, it is better to summer fallow, then cultivate thoroughly and hoe during the entire season, or sow with oats, plow when harvested; disk and harrow for the remainder of the season. Follow with a thick growing crop like sorghum or rape. The method used for Canada thistle may also be applied.

MORNING-GLORY

The morning-glory, though a troublesome weed in many parts of the state, does not seem to be quite as pernicious in its character as quack grass. In response to the queries sent out it is found that the best treatment that can be given the morning-glory is to turn it into pasture. Cattle, sheep and hogs are very effective in keeping this weed down. One writer states that by keeping it in pasture four or five years the weed is killed. As to cultivation, this should be thorough. The plowing should be done as soon as the grain is removed in July or August, but it need not be deep, as the roots extend several feet into the soil and can not be reached by plowing. Where the weed is common the plowing should be followed by disking and harrowing

and the roots should be exposed to the sun. One correspondent recommends corn, oats, and pasture. Another recommends millet, sorghum, and buckwheat as effective in the destruction of the weed. When a cornfield contains a considerable amount of the morning-glory the cultivation must be frequent and the hoe should follow the cultivation, especially to destroy the plants which make their appearance around the hills.

INDIAN MALLOW OR BUTTER PRINT

Much complaint has come to us about Indian mallow or butter print. This weed, which is very common in many parts of the state, is of



Indian Mallow.
Abutilon Theophrasti.

course readily destroyed by cultivation. The only trouble is that so much of the seed retains its vitality for a considerable length of time. Ewart found that some seeds of a variety of this weed germinated after half a century. One difficulty encountered is that the small plants coming up after corn is "laid by" produce seed to sow the soil. The best treatment for this plant is to get the field into meadow or pasture, leaving it in this condition for a number of years and then planting to corn and following the usual rotation.

BURDOCK



Burdock.
Arctium Lappa.

This is one of the common weeds of Europe and America, being found about fields, gardens, and roadsides.

It is a coarse branched biennial from one to three feet high; leaves large, heart-shaped, whitish beneath; heads of purplish or whitish flowers in clusters. The heads are covered with hooked barbs, or tips, and may prove to be a serious annoyance to animals by clinging to their hair and fleece.

The burdock bears fruit the second year and continues to flower till frost. The seeds are light brown marked by darker spots and lines.

This weed is easily destroyed by cutting out the crown some time during the early summer.

WILD TIMOTHY OR DROP-SEED GRASS

This station has received many letters complaining about this weed. The character of the "roots" is so different from that of the roots of quack grass and the other perennial weeds that, as we have mentioned before, it is not difficult to exterminate. The roots of this weed and the allied species are more or less clustered. In an experiment conducted to exterminate this weed we found that by giving a shallow plowing of four or five inches and, harrowing to expose the roots to the sun, they were killed, no growth making its appearance during the rest of the season. Of course this is not effective during rainy weather, and it may be necessary to cultivate two or three times during the summer and fall.

SQUIRREL-TAIL OR WILD BARLEY



Squirrel tail.
Hordeum jubatum.

Squirrel-tail or wild barley is a most pernicious weed along road sides and in pastures and meadows; pernicious because it not only prevents the growth of the better grasses but it is injurious to live stock. As this weed is most common in the pasture, the best way to treat it is to mow the pasture before the grass has matured its seed. Since this weed is an annual, or winter annual, this would effectively dispose of the plant were it not for the fact that the seed is blown in from neighboring fields and road-sides. Cultivation will readily destroy the weed and where it is abundant in fields shallow cultivation followed by the disk and harrow should be effective.

FOXTAIL

It is not generally recognized, but it is doubtless true, that more money is spent in the extermination of foxtail than of any other class of weeds we have in the state of Iowa, yet they are all easily destroyed. One of the best and most effective methods of destroying the foxtail is by plowing the small grain field as soon as the grain is removed. If this is not done a large amount of seed is produced. After this plowing in the fall the field should be disked and harrowed in the spring and then planted to corn. The corn should be cultivated as frequently as possible, at least four or five times. This method should prove effective for the destruction of foxtail and pigeon grass.

SHOOFLY

Shoofly or bladder ketmia has long been known as a troublesome weed in some parts of the United States, especially southward. At one time it was widely scattered by seedsmen because it was cultivated for ornamental purposes. It is a low, rather hairy annual, with the upper leaves three-parted. The large, sulphur-yellow flower with a black spot, surrounded by a loosely inflated calyx, renders it easy of detection. Flowers do not remain open very long. The seeds are blackish, kidney-shaped, and roughened.



Shoofly.

Hibiscus Trionum.

One correspondent writes that he has tried to exterminate this weed by keeping his ground clean, but the weed kept coming up. The weed is not difficult to exterminate, but the great trouble with this and the Indian mallow, is that the seeds retain their vitality for a long time. How long has never been determined, but there are evidences that the weeds will spring up for years after they have once gotten into the soil. We would suggest, when the weed is common, that thorough cultivation be given and that it be followed subsequently with a pasture crop. The pasture crop will subdue the plants or keep them down.

CHICORY

Chicory has long been recognized as a troublesome weed in the east, but it is only in recent years that it has attracted attention in this state. It is common in alfalfa growing sections of the country as well as the clover sections. The plant is easily recognized by the blue flowers and lower root leaves, which resemble those of the common dandelion. The upper leaves are more or less sticky and clasp the stem. The plant contains a milky juice. Chicory is not difficult to destroy where rotation of crops is practiced. Though a perennial, the roots are easily killed by successive cultivation.



Chicory.

Cichorium Intybus.

DODDER



Field Dodder.
Cuscuta arvensis.

Two species of dodder have been widely scattered in this state, namely, the clover dodder and field dodder. The dodders are easily recognized by the twining habit of the plant. They are leafless, excepting for small scales on the stems, and the plant is of a reddish or yellowish color. The dodder plant pierces the clover or alfalfa and takes its nourishment from the plant on which it occurs. This parasite spreads so rapidly that under favorable conditions a large area may be destroyed in a short time.

Where this parasite occurs the patches should be mown with a scythe and the material burned. Where a field is badly infested the whole growth should be plowed under after the early crop is removed, before the dodder has gone to seed.

Plant only clean seed.

WILD CARROT

Wild carrot has become more widely distributed with clover seed than any other weed in the state. It is an extremely common weed in the east where it has long been known as troublesome to crops. Wild carrot is a biennial with bristly stem, finely divided leaves, and numerous white flowers in umbels. After flowering the flower stalks bend inward, becoming strongly concave. The seed is flattened with marginal bristles. In commercial seed these bristles are often broken off.

This weed is a most objectionable one in the meadow and pasture. It is not, however, difficult to exterminate when taken in time. Thorough cultivation before sowing the crop, and thorough cultivation of the corn field, will destroy the weed. Do not permit any of the plants to go to seed in the clover or timothy meadow.



Wild Carrot.
Daucus Carota.

FEEDING CORN SILAGE TO FARM ANIMALS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Animal Husbandry Section



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FEEDING CORN SILAGE TO FARM ANIMALS

Breeding Herd of Beef Cattle, Fattening Lambs, Yearling Sheep, Horses and Hogs. By W. H. Pew.

Fattening Cattle, Wintering Ewes and Lambs. By John M. Evvard.

Dairy Cattle. By H. H. Kildee.

The silo has, for a long time, been proving its value to the live stock farmer. It should form a part of the permanent improvements of every live stock farm. Experienced feeders from all parts of the country testify to the good qualities of silage.

Information concerning the use of this feed is being sought from every available source. In answer to the many questions that are being daily received at the Iowa Agricultural Experiment Station, this bulletin has been prepared. Corn silage only is discussed herein because it is the staple silage of Iowa.

[Breeding Beef Herd Cows]

The feeding of the breeding herd of beef cows during the winter months must be governed by the condition of the cows at the time of going into winter quarters. If the cows are dry at the beginning of the winter they must necessarily be fed somewhat differently than if nursing calves.

Assuming that the cows are in thrifty condition after the calves are weaned in the late fall, and that they are to drop calves again in the early spring, the feed should be such as to keep them gaining until this time. For cows in such condition corn silage may make up the greater part of the ration and will be found to be one of the best feeds available. It should be supplemented with such other roughages as alfalfa or clover hay and corn stover or oat straw. For the dry cows a ration of thirty to thirty-five pounds of corn silage, five to eight pounds of clover or alfalfa hay, together with what corn stover or oat straw they will eat, will prove very satisfactory. Such a ration should keep the cows gaining at the rate of more than one pound per day.

If the cows are nursing fall-born calves, silage will so stimulate the milk flow that larger and more thrifty calves will be the result in the spring. Some concentrated feed should now be fed in conjunction with the silage. Cottonseed meal, one and one-half to two pounds per day for each 1,000 pounds live weight, together with silage and other roughage makes a very satisfactory ration. Oats (at the present prices) can well be used in the ration.

By the liberal use of silage the cost of wintering the breeding herd of beef cows can be cut down nearly one-third; also the cows will come through the winter in better condition.

Heifers and Bulls.

As soon as the calves are weaned in the fall, silage should be given them quite as freely as they will eat it. Necessarily for best results they should have grain of a growing character, together with clover or alfalfa hay.

During the second winter the heifers to be used in the herd for breeding purposes will do very well on the following ration:

Silage, 20 to 25 pounds.

Clover or alfalfa hay, 8 to 10 pounds.

Corn stover or straw, what they will consume.

If desired to have the heifers in somewhat high condition it will be necessary to feed some extra grain.

As a rule the young breeding bulls are required to be in higher condition than the heifers, hence it will be necessary to give them grain in amounts to suit the conditions. Silage can be utilized in the ration to good advantage.

It is not usually desirable to keep the aged herd bull in high condition. His winter ration can be made up of silage and other roughages at hand, preferably clover or alfalfa hay and mixed grain in amounts needed for the required condition. If the bull is necessarily closely confined, the amount of silage had best be considerably reduced.

FATTENING CATTLE

Corn silage should be put into the feeding program of every Iowa beef producer if he wants to fatten cattle economically and efficiently. That corn silage is our most profitable cattle roughage has been clearly demonstrated at the Experiment Station as well as upon hundreds of Iowa farms.

The addition of corn silage to the ration not only decreases very materially the cost of gains, but usually makes them more rapidly. The steers are finished more quickly and ordinarily sell for a higher price than where clover is used as the roughage.

Fattening cattle of all ages utilize silage as their roughage ration. It is as good for the calf and yearling as for the two and three year old. All profit from its use.

Silage is practically one-third to two-fifths as valuable as clover hay for beef production. Silage at \$3.20 a ton and clover hay at \$7.66 a ton were equally efficient in fattening two-year-old steers in 1911-12 in our station tests. Ordinarily when clover is selling from \$10 to \$15 per ton, silage is worth from \$.50 to \$6.00.

That the corn grain which is put into the silo is not wasted our feeding records clearly show. Cattle receiving silage do not eat as much grain as hay fed cattle, the decrease being approximately equal to the amount of corn found in the silage.

For a short feed, silage is preeminently our most abundant and efficient roughage. The gains are not only more rapid than where clover or alfalfa is fed, but are made more cheaply. Furthermore, the selling price is markedly enhanced. Actual experiment has shown that as compared to clover in a ninety-day feed, silage cattle, rightly fed, will sell from ten to seventy-five cents higher per hundred weight.

For a long feed silage is quite efficient, producing, as compared to clover, both cheaper gains and a higher quality of finish.

Protein supplements must be fed with silage in order to make it an efficient fattening food. Cattle cannot be fattened economically on corn and corn silage. It is imperative and absolutely essential that protein concentrates such as cottonseed meal, cold pressed cottonseed cake, linseed oil meal or similar feeds be fed.

Some very good rations which have been tested out and found highly efficient, follow:

For calves.—Corn, full feed; linseed or cottonseed meal, 3 pounds per thousand pounds of live weight daily; clover or alfalfa at free will; oat straw at free will; corn silage twice daily, all that they will clean up in from thirty minutes to an hour.

The addition of dry roughages to the silage ration is profitable as all cattle seem to crave a certain amount of dry rough feed. Although clover and alfalfa are desirable oat straw may be profitably used in their absence.

Yearlings and two year olds or older will require about the same ration as calves with the exception that the protein supplement may be decreased somewhat. Two year olds should receive about two and one-half pounds of linseed or cottonseed meal per thousand pounds of live weight daily; yearlings about two and three-quarters pounds.

The average daily silage, hay and grain consumption of a two-year-old

steer weighing 1,000 pounds at the start, during a five-months full feeding period will approximate:

Shelled corn, 13 to 16 pounds.

Cottonseed meal or linseed meal, 2.7 to 3.6 pounds.

Clover or alfalfa hay, 3 to 5 pounds.

Corn silage, 22 to 35 pounds.

With silage as lone roughage the consumption will be about 28 to 35 pounds. It requires practically one and three-quarters to two and three-quarters tons of corn silage for a five months' feed for a two year old.

In the absence of any dry roughage such as clover, alfalfa or oat straw, corn silage may be used as the lone roughage. Some dry corn stover should be utilized if possible. In case of lone silage feeding, however, one had best increase the protein concentrates slightly.

In what quantities throughout the feeding period shall we feed silage? Our experience clearly shows that silage should be fed very heavily in the early part of the feeding period to insure most efficient results. The grain at this time may be somewhat limited. We put our steers upon a full feed of good quality silage the very first day and have never had any difficulty. Silage is a roughage and may be so handled without danger. To insure quick and economical finishing, the silage is best decreased somewhat at the close of the feeding period and the grain increased accordingly. Cattle, when nearly finished, tend to eat too much of the bulky, watery, palatable silage, thus leaving too little room for concentrated grains, a consumption of which is highly imperative at this time.

The shrinkage of silage fed cattle is not heavy as is ordinarily supposed. Silage fed cattle do not shrink any more than dry hay fed ones. Our results clearly indicate that cattle receiving both silage and dry roughage during the feeding period, shrink less than those fed on either dry feed or silage alone.

SILAGE FOR DAIRY CATTLE

The value of silage was first realized by dairy farmers for nowhere is the silo so much a necessity as upon the dairy farm. And no dairy farm is complete in its equipment that does not have at least one silo for winter feeding and one with a smaller diameter for summer feeding.

The characteristics of good corn silage make it preeminently a feed for dairy cattle. It is palatable, succulent, bulky, beneficial to the digestive tract, and economical. These are among the leading characteristics of the ration which is essential to the largest and most economical flow of milk. In fact, most dairy farmers in the corn belt realize that to secure the largest possible profits from a herd of cows they must feed corn silage. In regions where corn cannot be grown successfully for silage, many dairy men have silos in which they cure other crops.

Experiments carried on at the different experiment stations show conclusively that silage is far superior to shock corn or hay in milk production. Silage fed cows produced from eleven to thirteen per cent more milk than cows fed fodder from the same acreage.

Effects of Silage on Milk.

Contrary to the opinion formerly held the milk from silage fed cows is not inferior in flavor or odor to the milk from cows fed dry feed. The condensed milk companies which formerly did not favor milk from silage fed cows, are now advising their patrons to put up silos.

Great care should be taken, however, to prevent the odor of silage from contaminating the freshly drawn milk which takes up odors very quickly. It is best to feed the silage after milking and just what will be eaten up clean at that feed. The silos should be shut off from the barn proper. The idea still held by some, that corn silage will destroy the teeth and digestive tract of the cow and induce such diseases as tuberculosis, is erroneous.

Silage in the Winter Ration.

The principal reason why a dairy cow increases her milk flow when she is turned out to pasture in the spring is that she is receiving

a succulent feed. Thus if we wish to secure a large and persistent flow of milk during the winter months we must feed some succulent feed that will take the place of the pasture grass of summer. The two most common succulent feeds for winter are corn silage and roots. Experimental work has proved that the silage yields more heavily per acre, costs less and gives equal results from similar weights of dry matter.

One of the chief reasons why so many of our cows are unprofitable is that they lack persistency or do not keep up their flow of milk for a long period. While this is largely due to inherited characteristics, yet if all cows were properly fed on corn silage and other desirable feeds, much less trouble would be experienced in trying to keep cows up to their normal flow. Silage and alfalfa or clover hay should form the basis of our rations for dairy cows in winter. A good ration would be twenty-five to forty-five pounds of good corn silage, all the alfalfa or clover hay the cows wish, or ten to fifteen pounds, and seven pounds of grain for each pound of butter fat, or one pound of grain for each two and one-half pounds to four pounds of milk produced, depending upon the amount and richness of the milk.

Summer Feeding.

During the latter part of July and the month of August, the pastures are usually very short, due to hot weather and lack of rainfall. If we are to keep up the flow of milk at this critical time we must supply additional feed. There are many soiling crops which will supply the necessary feed in acceptable form, but most of them require more labor in getting them to the animals than the average farmer can spare at this busy season of the year. Therefore, a silo small in diameter filled for summer use is the most satisfactory and economical solution of this problem, on the average farm. The value of silage at this season does not lie solely in the temporary increase in milk flow, but we know that if a cow once declines in her milk flow it is practically impossible to bring her back to normal for the remainder of her lactation period.

Feeding Young Dairy Animals.

Silage also plays a very important role in the most economical and efficient ration for young, growing dairy animals. It has a very beneficial effect upon the system in keeping the digestive organs in the best of condition and as an aid in developing large digestive capacity. In attaining this last effect it is materially aided by alfalfa or clover hay. When these feeds are given it is not necessary to feed very much grain to the animals after the end of the first year.

A good winter ration for yearling dairy heifers is corn silage, fifteen to twenty pounds, alfalfa or clover hay, eight to ten pounds, grain mixture consisting of equal parts corn, oats and bran, two pounds.

Silage for Bulls.

Dairy farmers are practically unanimous in the opinion that a too liberal ration of silage should not be fed to the herd bull. When so fed the animal is usually rather heavy middled, sluggish and slow in breeding. The large amount of silage distends the middle unduly and does not supply the balance of nutrients necessary to keep the animal vigorous and active in service.

BREEDING FLOCK

Is corn silage a safe feed for the ewe carrying lamb? Yes, if intelligently fed. There has been some prejudice against corn silage as a pregnant ewe roughage, but our experimental results have clearly shown that silage is not only an efficient roughage, assisting in the production of strong, healthy lambs, but is a cheap feed.

Three bunches of 150-pound ewes were wintered in 1910-11 upon rations in which clover was compared with silage. The results briefly are as follows:

Lot 1.—Clover, 2.5 pounds, plus .9 pounds of a grain mixture of corn, 4 parts; oats, 2 parts; bran, 1 part. The lambs averaged 8.192 pounds each at birth, 100% of which were strong.

Lot 2.—1.84 pounds of clover, plus 3.25 pounds of silage in addition to .3 of a pound of a grain mixture of corn, 1 part; oats, 2 parts; bran, 1 part. The lambs averaged at birth 8.636 pounds each, 100% of which were strong.

Lot 3.—5.6 pounds of silage, plus $\frac{1}{2}$ pound of a mixture of oats and bran, equal parts. These lambs averaged 7.8 pounds each at birth and 100% of them were strong.

Counting shelled corn at 40 cents a bushel, oats at 30 cents, bran at \$1.25 per cwt., clover at \$10.00 a ton and silage at \$2.50 a ton, and crediting the gains made upon the ewes at 5 cents a pound, the daily maintenance cost in the clover lot was 1.37 cents; where both clover and silage was used, 1.02 cents; and where silage was used alone with bran and oats, .78 cents.

The rations that contained the largest proportions of silage were clearly the cheapest. The size of the lambs, as well as their general thrift and vigor, etc., was greater where both silage and clover was allowed as compared to either alone.

The silage was tested again in 1911-12, being compared with clover and alfalfa. The results show clearly that the silage rather tended to increase the vigor of the lambs as well as their size at birth. Where the large proportion of silage was fed the cheapest lambs were produced.

A very effective and safe ration for 150-pound breeding ewe would consist of the following:

Corn silage, 3 to 4 pounds.
Clover or alfalfa, $\frac{1}{2}$ pound.
Oats, $\frac{1}{2}$ pound.

If the feeder wishes to use more silage it would be advisable to secure some oil meal or cottonseed meal, the former preferred, to feed in conjunction.

Silage fed ewes giving too much milk at lambing time should be allowed a limited ration of silage previous to the time of birth. The flock master must always bear in mind that silage is a milk producer and govern his feeding accordingly. No such difficulties have been experienced in the Experiment Station flock.

The feeding of corn silage as an exclusive roughness for the wintering ewe is not to be advised. Some dry roughage should be always provided, preferably the legumes, clover or alfalfa. Soy bean or cowpea hay is good, oat straw is fair. However, if other rough feeds than silage are not available, a ration of five pounds silage, plus one-half to two-thirds of a pound of grain mixture of shelled corn, one part; oats, two parts and oil meal one part, will give good results. Cottonseed meal may be supplemented for oil meal, but ordinarily is not so good pound for pound.

How shall we winter the ewe lamb that is to become a member of the breeding flock? We have compared rations of clover versus clover and silage versus silage and find that where both clover (alfalfa, soy bean or cowpea hay would do as well) and silage is allowed in conjunction with a suitable grain ration that the cost is not only decreased but that the lambs are brought through the winter in better shape than if clover alone is used.

Last year we fed two lots of lambs upon the same grain ration of oats, nine parts, and oil meal, one part, one lot receiving clover hay alone and the other clover and silage. Their gain and feed record is given:

Silage is Added to Clover With Profit.

	Daily gain	Daily grain	Daily Roughage
Clover.....	.224	1.34	1.34
Clover and Silage.....	.233	1.34	1.00 Clover .80 Silage

Notice that .8 of a pound of silage replaced .34 of a pound of clover. At this rate a ton of silage is equal to practically two-fifths of a ton of clover or, in other words, two and one-half tons of silage is equivalent to a ton of clover. The lambs getting silage in addition gained somewhat more rapidly

and came through in the spring much thriftier than the clover alone lot.

The time has come when every corn belt farmer who is in the sheep business should preserve a part of his corn crop in the silo. It means much in the efficient production of mutton.

FATTENING LAMBS AND YEARLING SHEEP

Some prejudice is found in feeding silage to fattening sheep, but when it is found that gains are increased by the silage ration and also materially cheapened, this prejudice will not long remain. Some care must be exercised in getting lambs onto feed when silage is used, so as to prevent scouring. The amount of the daily ration will depend upon the size of the lamb. For lambs weighing sixty-five to seventy pounds, shelled corn or mixed grain (depending upon the price of feeds) one and one-fourth to two pounds, corn silage, one and one-half to two pounds, alfalfa or clover hay, one-half to one and one-fourth pounds will make a satisfactory fattening ration.

Yearling sheep will require more feed both of grain and roughage. A daily ration of one and one-half to two and one-fourth pounds of grain, two to three pounds of silage and three-fourths to two pounds of clover or alfalfa hay would prove satisfactory.

HORSES

Much discussion has arisen concerning the feeding of silage to horses. At the outset a good quality of silage, absolutely free of mold, is required. Some farmers have fed silage to brood mares and horses at rest during the winter with good results. On the other hand, some have lost horses on account of the molds which silage sometimes contains. If fed to horses of this kind, five to ten pounds per day with grain and other roughage is all that should be fed until more data is at hand.

The Pennsylvania Experiment Station fed silage to fattening geldings with quite satisfactory results. It is hardly to be expected that silage would prove efficient for horses at heavy work.

HOGS

Silage is too bulky, too fibrous and low in digestible nutrients to prove satisfactory for growing and fattening swine. The hog has a digestive apparatus suited largely to concentrated feeds. Old sows will eat some silage; however, if fed to them, it should constitute only a small portion of their ration.

BACTERIA AND SOIL FERTILITY

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Agronomy Section
Soils



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BACTERIA IN RELATION TO SOIL FERTILITY

BY P. E. BROWN.

The problem of obtaining maximum crops is centuries old but the agricultural world is still awaiting its solution.

It is known now that the crop any soil will yield under particular climatic conditions depends on the character and condition of that soil. If the soil is poor and infertile, the crop may be expected to be small; if it is rich and climatic conditions are favorable, the yields should be large. The real problem, then, is how to make the soil fertile and how to keep it so. If it is poor, then improvement is necessary; if it is good, further improvement may pay. There are probably few soils so poor that proper methods cannot put them on a paying basis; on the other hand, there are no soils so rich that they will always continue to be fertile.

Therefore, a study of soil fertility, or the crop producing power of a soil under given climatic conditions is of vast importance. Men must have knowledge of the fertility of a soil if they would properly regulate its **support power** so that the needed supply of plant food may be available for crop production.

Plant food consists of those chemical elements which are essential for the growth of plants and includes a large number of substances. Among these, nitrogen, potassium, phosphorus, and sulfur are most likely to be lacking in soils. In rare cases other elements may be deficient, but in normal soils, if enough of these four elements is present in a **soluble, available** form, the support power of the soil is satisfactory.

Many soils contain enough of these four necessary elements but they are locked up in an insoluble and unavailable form and hence must be changed and made soluble to be of use to crops. How is this change accomplished? What determines the production of soluble plant food in the soil? What regulates the support power of the soil? These are the questions which require a definite answer.

The factors which bring about the change of insoluble substances into soluble in the soil, may be grouped into three classes, physical, chemical and bacteriological.

The physical factors, such as light, heat, water, air, etc., and the chemical factors, such as soil acidity or sourness, the character of the chemical compounds present, etc., have been known and studied for many years. The bacteriological factors have come into prominence only quite recently, but now they are recognized to be of as much, if not more importance than the other two groups.

It has been well said that these three groups of factors working

together constitute the "commissary department for the army of plant life."

While, therefore, it is quite generally known now that the soil is the home of myriads of microscopic plants called bacteria, and that these have much to do with fertility, there is still a great deal of haziness about the subject in the public mind.

This circular is intended to clear up this haziness and to present in plain terms our present knowledge about bacteria in the soil and the part they play in making plant food available.

FACTS ABOUT BACTERIA

Before considering the part which bacteria take in liberating plant food it is well to bear in mind the fundamental facts about bacteria.

Bacteria are minute plants, consisting of single cells. These cells are made up of a cell-wall, and the living substance or protoplasm within the cell-wall. In the protoplasm the life processes are carried on. When food is absorbed, it passes into the cell through the cell-wall and the necessary portions are taken up by the protoplasm while the waste is eliminated, passing out through the cell-wall.

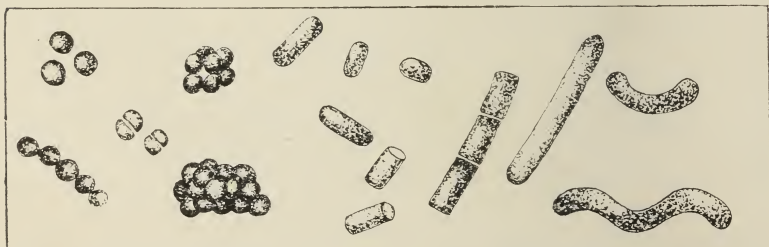


FIG. 1.—Types of Bacteria, Cocci, Bacilli and Spirilla from left to right, many times magnified.

Types. There are three main types of bacteria grouped according to form. They are the **cocci** or spheres, the **bacilli** or rods, and the **spirilla** or spirals. These groups have been popularly described as billiard balls, lead pencils and corkscrews. By far the largest number of soil bacteria belong to the group of bacilli or rods.

Multiplication. These simple organisms multiply by **fission**, that is, one cell divides into two equal parts, which may separate or may remain united. The spherical bacteria, due to their method of multiplication, frequently appear as packets of varying numbers of organisms, while the rods and spirals appear singly or in chains.

Rate of Increase. The splitting of one organism into two may be completed in twenty minutes to one half hour under very favorable conditions. At this rate, in one day one organism would become about 300,000,000,000,000. As a matter of fact, however, such a rapid multi-

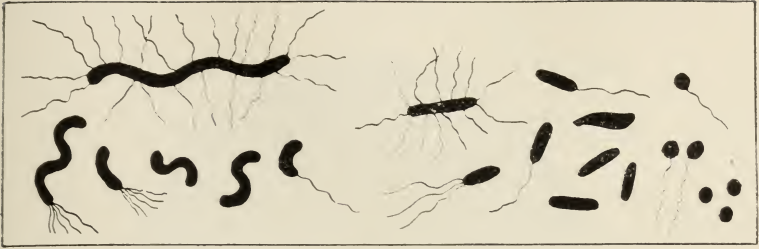


FIG. 2.—Motile and non-motile Bacteria, showing types of flagellation.

plication cannot occur, as food conditions do not remain satisfactory and the growth of the organisms gives products that restrict development.

Size. Bacteria are very small, ranging from 1-50,000 to 1-1,000 of an inch in length and averaging about 1-25,000 of an inch.

Motion. Many bacteria have **flagella**, or long thread-like appendages, by means of which they move about freely in any liquid in which they may be growing. These flagella may be attached in various ways, singly at the end of the organism, in tufts of several at one or both ends, or scattered indiscriminately over the organism.

Sporulation. Some bacteria under certain conditions, produce so-called **spores**, or cells surrounded by a very resistant cell-wall. They will remain alive practically indefinitely if not exposed to extremes of heat or cold and if kept dry; and when placed under favorable conditions will germinate and produce active bacteria again.

Sterilization. Sterilization is any process whereby bacteria are killed. The methods of sterilization which may be employed, depending on the materials which are to be freed from bacteria, are dry heat, steam under pressure, intermittent sterilization, which consists in heating at the temperature of boiling water for one-half hour on three successive days, chemical substances, sunlight, etc.

Cultures. Knowledge about sterilization, the food needed by bacteria, and other necessities for their growth, is used in the laboratory by growing bacteria on **culture media**, that is, any substance which will support their growth. Such a growth is called a **culture**, and when only one kind of organism is present, such a culture becomes a **pure culture**.

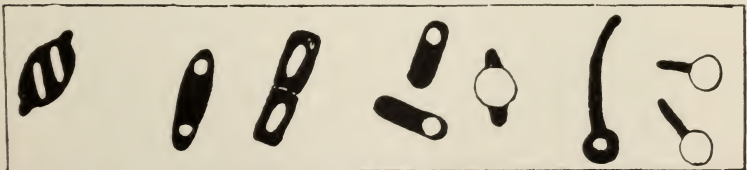


FIG. 3.—Spore production, showing method of production by various Bacteria.

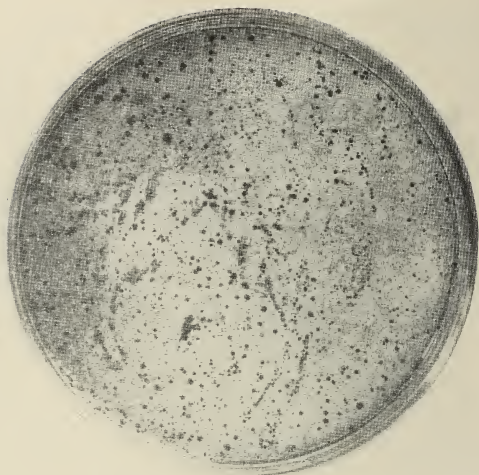


FIG. 4.—A pure culture of *Bacillus prodigiosus*, an organism that produces red pigment.

Classes. All bacteria may be included in one of two large classes depending on their functions, or the character of their activities. These are the **parasites** and the **saprophytes**. The parasites include all the disease producers. The saprophytes are the decay producers. Many people think of all bacteria as connected with disease. They know that typhoid, diphtheria, tuberculosis and other diseases are caused by bacteria and fall into the error of believing that all organisms are active in causing some dread disease. Such is far from being the case, however. The saprophytic, or decay bacteria, are invaluable. They have been called the "link between the world of the living and the dead." They transform dead materials back into living matter and thus complete the cycles through which, in nature, all substances must go. Bacteria are everywhere, in the air, the water, the soil, but contrary to the popular belief, which is that we are becoming "bacteria crazy," such general distribution is no cause for alarm but rather a source of benefit. A bacteria-free world would soon be a dead world.

BACTERIA IN THE SOIL

Enormous numbers of bacteria inhabit the soil, some of them harmful, but the vast majority beneficial. Actual counts have shown that the numbers present in soils may vary from a few thousand per gram (about 1-30 of an ounce) to over fifty million per gram.

CONDITIONS AFFECTING THE GROWTH OF BACTERIA.

There are certain conditions affecting the growth of bacteria. A discussion of these has purposely been omitted up to this point in

order to consider them from the standpoint of the soil. In other words, the bacteria in the soil, just as in any other environment, are greatly influenced by certain physical and chemical conditions. These conditions are **moisture, temperature, aeration, reaction, and food supply.**

Moisture. A proper amount of water in the soil is as necessary for the growth of bacteria as for crops. Either excessive moisture or severe drought interferes with bacterial growth very considerably. Many organisms are killed by too much moisture, many others, by insufficient moisture. Merely drying out a soil by exposing it to the air, however, will not kill the bacteria present. Such soils, kept for years in an air-dry state, have been shown to contain certain bacteria which had evidently been in a dormant condition. Such farm practices as drainage, which removes excessive water, or cultivation, which prevents undue loss of water by evaporation, have an important influence on the bacteria in the soil. Recent work has shown that small variations in moisture are of little influence on bacteria in the field, other factors apparently being of greater importance, but when variations are large, then moisture becomes the governing factor.

Temperature. Every organism grows the best at a certain temperature which is called its **optimum temperature**. Each also has so-called **maximum** and **minimum** temperatures at which points growth ceases. The optimum temperature for most soil organisms ranges from 65°-90° F., although of course there are exceptions to this statement. Most organisms are not killed by excessive cold but merely remain dormant. In fact, it has been shown recently that certain

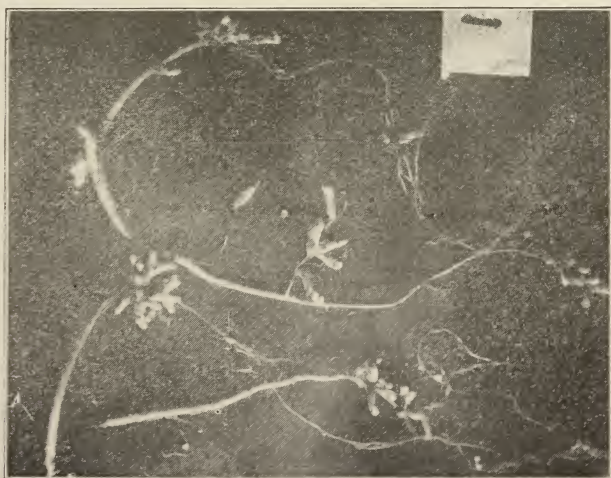


FIG. 5—Nodules on Alfalfa roots.

bacteria are alive and active in soil in late winter, at a soil temperature somewhat below the freezing point. It is generally considered, however, and with reason, that the greatest bacterial activities occur in the soil during the summer and are then of the most significance. Those occurring during the winter are of importance only when fall applications of manure are made.

Aeration. Depending upon their requirements as to air, bacteria may be divided into three classes: the **aerobes**, which require air for their growth; the **anaerobes**, which grow only in the absence of air, and **facultative anaerobes**, which prefer air, but will grow without it. In general it may be said that the beneficial bacteria in the soil need air. Hence in heavy clay soils where there is not enough air, methods which increase the circulation of oxygen in the soil, increase bacterial activities; these increase the solution of plant food and this ultimately increases crop production. On the other hand, if there is too much air present, as in light sandy soils, the bacterial activities will be too great and the humus will be burned up too rapidly, plant food will be produced in too large quantities to be utilized by the crops, and more or less extensive losses of valuable soil elements will occur. Methods must be practiced with such soil, which will make it more compact and prevent the excessive circulation of air, reducing bacterial activities to what is best.

Reaction. The reaction of a soil is its relative acidity, or "sourness" or alkalinity. The reaction means much from the bacterial standpoint. Soils which have become acid or sour are notably unproductive and this is largely due to the fact that the growth of beneficial bacteria in such soils is checked. Some bacteria are probably favored by acid conditions but those organisms which bring about the solution of the important plant food constituents refuse to develop in acid soils. Such an unfavorable condition may be remedied by application of ground limestone or caustic lime in varying amounts. Applications of ground limestone to sour soils have been shown to be followed by increased beneficial bacterial activities and later by increased crop production. (Further information regarding application of lime to Iowa soils may be found in Circular No. 2 of the Iowa Agricultural Experiment Station.)

Food Supply. Bacteria require food for growth just as truly as do crops, and it is because of this need that they influence fertility. In the process of taking up food from the chemical compounds in the soil, the bacteria cause changes in the compounds, making them soluble and hence available for the growth of plants. Most soil bacteria live principally on organic matter, or humus, and the products of their own activity. Some few species are known which live in the absence of organic materials. Usually, however, soils without humus are without bacteria. Increasing the humus content, therefore, may be expected to increase the bacterial life. That is actually the case up to a certain limit, which varies widely for different soils.



FIG. 6.—Nodules on Soy Bean roots.

Beyond a certain point, however, the amount of food ceases to govern bacterial growth and a lack of moisture or the presence of acidity or sourness may offset the benefits of a greater food supply. The minerals in the soil solution also have some influence on the bacteria. Certain groups are favored by some substances and others restricted or killed by certain other chemicals. Thus the bacterial floras of the soils of wet and dry regions are quite different.

The bacteria furthermore not only act on the humus or organic matter in the soil and bring about its solution in the process of obtaining their food, but they also attack the mineral portion of the soil and change insoluble portions of that into soluble.

BACTERIA AND THE TRANSFORMATION OF PLANT FOOD

We have considered the fact that the fertility of a soil is determined very largely by the bacterial activities going on therein. We have discussed briefly the nature of bacteria, their form, size, multiplication, etc., the numbers present in the soil and the effect of various physical and chemical conditions in the soil on their development. We have found also that in the course of their life activities, bacteria attack the organic and mineral portions of the soil and transform insoluble constituents into forms soluble and available for crop nourishment. It now remains to show how this change is ac-

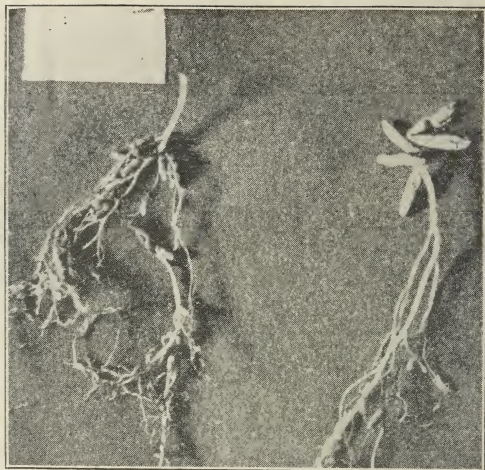


FIG. 7.—Nodules on Red Clover roots.

complished, to consider the various stages through which the transformation proceeds, to discuss the bacteria involved, and to reach some conclusion regarding the importance from the fertility standpoint of the changes brought about in this way in the store of plant food constituents.

THE NITROGEN PROBLEM AND ITS SOLUTION.

Soils are very apt to be deficient in nitrogen. This element, then, is generally the limiting factor in the growth of crops. Formerly the lack of nitrogen in a soil was supplied by application of nitrate of soda, which was obtained from the nitrate beds in Chili. With the increasing demands for nitrates, the amounts taken yearly from the nitrate beds were enormous and it was estimated that in a very short time the deposits would be exhausted and the world would face a nitrogen famine. Of course, other nitrogenous materials were available for manure, but in such small amounts that they would be merely a drop in the bucket in supplying the demands of the world.

It was just at this crucial time that soil bacteriologists came to the rescue and quieted the general fears by showing that certain species of bacteria living in soils have the ability to draw upon the inexhaustible supply of nitrogen in the air (which contains 79% nitrogen) and fix it in the soil in a form available for plants. Thus the nitrogen problem was solved and there need be no fear of a nitrogen famine.

NITROGEN FIXATION.

There are two classes of bacteria which are thus able to utilize

the nitrogen of the air in their growth: First, those which live entirely dependent on their own resources, and second, those which grow on the roots of legumes such as clover, alfalfa, etc. The first are said to live **non-symbiotically**, or independently, and are known as non-symbiotic; the second are said to live in **symbiosis** with the legumes, or in a state of mutual helpfulness and are called symbiotic.

NON-SYMBIOTIC NITROGEN FIXATION.

The first group of nitrogen fixers, or azotobacter as they are called is present in most soils. These bacteria fix nitrogen in amounts which have been estimated at from 15 to 40 lbs. per acre per year under ordinary conditions. One instance is on record where fixation took place to the extent of 100 tons per acre to a depth of a few inches. This of course was excessive and all vegetation was killed.

This single instance of "too much of a good thing" is not to be taken however as an argument against encouraging the activities of the azotobacter. Proper farm management includes many practices which encourage the fixation of nitrogen from the atmosphere. Thus the ordinary operations of tillage, which open up the soil and admit of a free circulation of air, encourage the growth of these free-living bacteria and bring about greater fixation of nitrogen from the atmosphere. So also liming as a remedy for acidity increases the amount of nitrogen in the soil by causing a greater growth of azotobacter. In other words, any practice which brings about better physical and chemical conditions in the soil for the growth of bacteria increases the activities of this particular group of organisms and the soil gains in nitrogen content.

SYMBIOTIC NITROGEN FIXATION.

The beneficial effect of clover growing on soils was known many years before it was satisfactorily explained. The mystery was not cleared up until the bacteriologists found that certain bacteria were associated with legumes and that these bacteria took nitrogen from the air and fixed it in the soil.

Legumes will grow and flourish on soils that have absolutely no nitrogen if the proper bacteria are present and the legumes become **inoculated** with these bacteria. In this process of inoculation the bacteria enter the roots of the legumes. The plants aid the process by a softening of their tissue and then in so-called "infection-threads" the bacteria pass from cell to cell. They gather at a particular spot and, nourished by the plant, multiply to a large extent and form what are known as **nodules**, or swellings on the roots. As soon as the organisms begin to multiply they begin to take nitrogen from the atmosphere and to supply it to the plant. The plant in return supplies the bacteria with the necessary carbonaceous food and a close union for mutual benefit is thereby established. So the legumes draw but a small proportion of their nitrogen from the soil and if the

entire crop is turned under for a green manure, which is a common practice, there is a large gain to the soil in nitrogen.

Legumes will often grow without inoculation and in soils very rich in nitrogen will yield good crops. They then draw their entire nourishment from the soil. When that is the case the legumes have no advantage over the non-leguminous crop. But when legumes are inoculated they contain a larger percentage of nitrogen and the soil is not robbed of its stock of nitrogen.

SOIL INOCULATION.

The bacteria necessary for the inoculation of legumes are not always present in soils and hence we have to resort to what is known as **soil inoculation**, which consists in introducing the proper organisms into the soil. This may be done in two ways: By inoculating the seed with pure cultures, that is, cultures of the particular organism grown on some convenient medium, or by spreading on the land to be seeded, soil from a field where the particular legume to be grown has been successfully grown previously.

Several commercial concerns, the United States department of agriculture, and some experiment stations prepare cultures for the inoculation of legumes but none has as yet proved to be absolutely satisfactory. Cultures are not always certain of accomplishing inoculation and consequently we still recommend the use of soil for



FIG. 8.—Nodules on Crimson Clover roots.

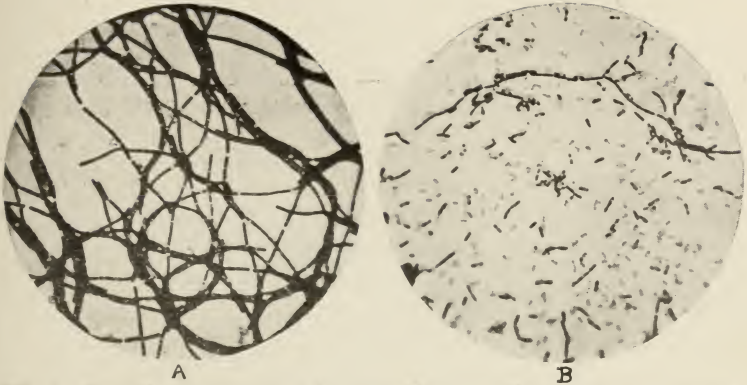


FIG. 9.—Stained preparations of *Bacillus Mycoides* (A) and *Bacillus Subtilis* (B) with spores, two prominent soil ammonifiers.

the purpose. Three hundred to 500 pounds of soil per acre should be uniformly distributed, just previous to seeding over the field to be inoculated, and disked in. In this way bacteria in an active state of multiplication are introduced without material change in the character of their surroundings and they become vigorous and easily enter the roots of the legume, insuring inoculation and a good crop.

AMMONIFICATION.

The activities of soil bacteria with regard to the nitrogen problem are important not only from the standpoint of increasing the nitrogen content of soils through additions from the atmosphere but also in the change of organic materials into available forms.

Plant and animal remains in the soil, farmyard manure, green manures, or other organic materials added to the soil contain insoluble organic nitrogenous matter known as **protein** and these must be changed into soluble **nitrates** to be of use to plants. This solution is accomplished by the process of **decay**. Bacteria are the active agents bringing about this decay in the soil. Various groups of universally distributed organisms are involved. In the first place the insoluble proteins are changed into soluble **peptones**, these are changed to **amino acids** and these in turn to **ammonia**. This change of protein into ammonia is called **ammonification**, and it constitutes a vital stage in the production of nitrates in the soil. It is important also in that it brings about the formation and later the destruction of **humus**.

Humus is decaying organic matter in the soil. We know that the presence of a proper amount of humus and also the best rate of destruction are important factors from the physical and chemical standpoint in determining the fertility of a soil. The ammonifying bacteria attack the organic materials in the soil and bring about the

formation of humus. This action continues and if no more organic substances are supplied, the humus in the soil is used up. Furthermore, if the soil is too open, too much air is admitted and the bacterial activities are so strong that the humus is destroyed and fertility is lost. Thus in sandy soils it is very difficult to keep up the humus content and recourse is had to green manuring for upbuilding purposes. In ordinary soils, however, the destruction of the humus is not so rapid, but in any case if the soil does not receive additions of organic matter at more or less frequent intervals, it will become deficient in humus.

Introduction of barnyard manure brings about vastly increased bacterial action due to the large amount of organic matter added and also the large number of bacteria introduced. Thus the ammonifying power of a soil is increased by addition of manure. Liming also has been shown to increase the activities of the ammonifying bacteria and consequently to hasten the production of plant food. All tillage which admits air to the soil increases the ammonia producing power of the soil and later the nitrate production.

NITRIFICATION.

Ammonium compounds produced in the soil as just described never accumulate to any appreciable extent but are transformed into nitrates almost as rapidly as they are formed. This transformation is called **nitrification** and includes two stages: the change of ammonia to **nitrites** and then the oxidation of nitrites to **nitrates**. Two distinct classes of organisms are involved in the process and they are both of practically universal distribution.

All the farming operations which increase ammonification have a similar effect on nitrification, since nitrification starts where ammonification leaves off. Particularly necessary for nitrification, however, is the presence of lime in soils. This is due to the fact that nitrous and nitric acids are produced in the process of nitrification and if they are not neutralized by lime they accumulate and very quickly stop bacterial action.

The nitrifying bacteria are also sensitive to an excess of organic matter but the amounts present in ordinary soils are never large enough to depress nitrification.

It is evident then that the activities of both the ammonifying and the nitrifying bacteria are governed very closely by the climatic and farming conditions with regard to moisture, temperature, acidity, aeration, and food supply.

DENITRIFICATION.

There is one process which is the result of bacterial action and is deserving of mention here, if for no other reason than to set aside suspicions as to its common occurrence in the soil. It is **denitrification**. Denitrification is a process brought about by certain bacteria

leading to the loss of gaseous nitrogen into the atmosphere. If this loss in the field were considerable the importance of the process would be evident. As a matter of fact, however, the danger of loss is very remote. The conditions necessary for denitrification, which are excessive organic matter, large amounts of water, nitrates and the proper bacteria, are rarely met with in the soil. Only when exceedingly large amounts of fresh barnyard manure and sodium nitrate are applied together, a practice which is commonly condemned, could denitrification occur. Depression in crop yields which have sometimes been observed when large quantities of manure have been applied and which have been attributed to denitrification were more likely due to some other cause, perhaps to the soluble organic matter introduced. With ordinary applications of barnyard manure, the farmer need have no fear of losing nitrogen from his soil by this process.

BACTERIA AND MINERALS IN THE SOIL.

In the process of decay of which we have spoken, the destruction of the organic nitrogenous materials leads to the production of other compounds than ammonia and nitrates. Chief among these is **carbon dioxide**. Furthermore, the organic non-nitrogenous substances, such as starches, sugars, cellulose, etc., are destroyed in the general decay which occurs in the organic matter and among the variety of products which result we find various organic acids and particularly carbon dioxide. These organic acids and the carbon dioxide have the power of attacking insoluble mineral compounds in the soil and transforming them into soluble forms, available for plant food. Thus insoluble phosphates and potash compounds are acted upon and changed into soluble forms by the soil water carrying the carbon dioxide and organic acids in solution. Again we see that bacterial activities bring about the preparation of plant food.

The demands of various crops for sulfur has been the subject of recent investigations and it has been estimated that the supply of sulfates in the soil may be insufficient in many cases for the proper feeding of certain crops. A group of organisms occurring in the soil and known as the **sulfur bacteria** come into prominence here as the agency keeping up the proper supply of sulfates. When proteins decay, hydrogen sulfide gas is set free. This is taken up by the sulfur bacteria and oxidized to free sulfur which is in turn oxidized to sulfates. Increased decay therefore leads to increased hydrogen sulfide and this in turn to increased sulfates for plant food.

We may conclude, therefore, that all methods which increase the activities of the decay bacteria lead directly to an increased supply of available nitrogen, and indirectly to larger amounts of phosphorus, potassium, and sulfur becoming available for plant food.

CONCLUSION.

In conclusion the fact must be emphasized that the bacterial processes going on in the soil cannot be ignored in a consideration of its fertility. The physical and chemical character of the soil alone will not tell us its crop producing power and we must depend on the results of tests of bacterial activities. The recent development of methods in this direction gives us reason to hope that in the near future bacterial tests of fertility may become of considerable practical value.

From the practical standpoint, it should be evident that the greatest care ought to be exercised on every farm to maintain conditions satisfactory for the best growth of beneficial bacterial species. Moisture conditions should be governed as far as possible by drainage or cultivation, aeration should be carefully regulated to keep the destruction of the humus from proceeding too rapidly; and the reaction of the soil should not be allowed to become acid, adding lime if necessary to prevent it. If these conditions are carefully governed and the humus content of the soil is properly maintained by manuring with farmyard or green manure, and proper rotations containing a legume are employed, the bacteria can be depended upon to perform their part faithfully and well and the crop will not fail for lack of sufficient available nitrogen.

Furthermore, if chemical analyses have shown sufficient amounts of the necessary mineral plant food constituents, the bacteria under the optimum conditions just outlined will transform it into an available form to satisfy the needs of the growing crop.

In short, the relation between bacteria and soil fertility is very close and very vital and systems of permanent agriculture must rest firmly on a bacteriological basis to be of any value.

INOCULATION OF LEGUMES

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Agronomy Section
Soils



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THE INOCULATION OF LEGUMES

By P. E. Brown

The soil-enriching effect of the growth of clover and other legumes has been recognized from the earliest days of agriculture. Even ancient Roman authors emphasized their value in regular rotations. Since then the use of leguminous crops to increase the yields from soils more or less worn out has gradually gained in favor. By the early part of the eighteenth century, clover had replaced the older bare fallow as a means of restoring fertility and it was a very common crop. At that time it was practically the only important fertilizer known and it received much attention and many theories were advanced about its growth and action.

EARLY EXPLANATIONS OF THE EFFECT OF LEGUMES.

The explanations of the beneficial action of legumes were many and varied. The most common early idea was that the greater root systems of these plants brought up so much plant food from the lower soil layers that the succeeding crops were materially aided in their growth.

It was claimed later that all plants drew their nitrogen supply from the air and that the legumes, having broad leaves, took in more nitrogen and therefore left more in the soil for following crops. That this belief was wrong was soon shown when experiments proved that no other plants except legumes would grow in soils having no nitrogen unless that element were supplied to them in the form of nitrates. In the case of legumes it was not easy to draw conclusions for the results of various experiments were conflicting. Sometimes they would grow all right in soils containing no nitrogen and again they would not.

THE SOLUTION OF THE PROBLEM.

The problem was not solved until 1886. Then Hellriegel showed that the successful growth of legumes in soils containing no nitrogen depended on the nodules, or swellings, on their roots. Plants having such nodules grew well, even though no nitrogen was added to the soil; plants having no nodules died as soon as the little nitrogen in the seed was exhausted. It was clear, therefore, that the legumes which had nodules on their roots had some peculiar advantage, not only over all other plants, but also over other legumes on which no nodules were formed.

NODULES.

These nodules had been noticed many years before. They had been variously described as diseased roots, food store houses, or undeveloped buds, etc. More careful examination showed that they served as a home for bacteria, or minute microscopic plants. It was shown also that they consisted of pure cultures of bacteria, that is, they contained only a single kind.

Further experiments showed that when sterilized seed is planted in sterilized soil, that is, when seed and soil that have no bacteria are used, no nodules are formed on the roots of legumes. The peculiar power of legumes to grow on nitrogen-free soil was then shown to be due to the activities of bacteria which enter the roots, form nodules, take nitrogen from the air, and supply it to the plants in the necessary amounts.



Young Plants of Red Clover Well Inoculated.

RELATION BETWEEN LEGUMES AND BACTERIA.

The true relation between legumes and these bacteria was later shown to be one of mutual helpfulness, or symbiosis. The plants provide a home for the bacteria and also some food material and the bacteria in return place the great store of nitrogen in the atmosphere at the disposal of the plants.

Many experiments have since been carried on proving beyond doubt the correctness of these statements. The benefits to legumes from the nodules on their roots have been clearly shown. Indeed, these plants may grow more vigorously when they have abundant nodules than when nitrogen fertilizers are applied.

THE EFFECT OF LEGUMES ON SUCCEEDING CROPS.

The beneficial effects on succeeding crops due to the growth of legumes having many nodules has been demonstrated by comparing the yields of grain crops following such legumes with those of the same crops following other grains.

Increased yields were common on the soil which had previously borne the legume. This fact is of such general knowledge now that it is widely believed that proper rotations should contain a legume.

LEGUMES ACT LIKE A NITROGENOUS FERTILIZER.

Experiments carried on by many experiment stations in this country have shown that the growth of a leguminous crop acts like an application of a nitrogenous fertilizer. It has been estimated from the results obtained in sixteen states that the amount of nitrogen added to the soil by the growth of a well-inoculated legume amounts to 122 lbs. per acre. The Germans place their estimates somewhat higher, at 200 lbs. per acre. At this rate, it is evident that the growth of a crop of a nodule-bearing legume is equal to an application of 800-1000 lbs. of nitrate of soda which represents considerable money value at the present price of the nitrate.

METHODS OF SOIL INOCULATION

The importance of growing a legume in every rotation and the necessity of the legume having nodules on its roots, or being **inoculated**, if it is to take nitrogen from the air, are established facts. It is also clear that in many cases the bacteria necessary to produce these nodules are absent from soils and that in such cases the legumes draw all their nitrogen from the soil and therefore have no advantages over the more profitable cereal crops. These facts have led to the practice of **soil inoculation**, or putting into soils the necessary bacteria when they are lacking.

SOIL TRANSFER.

The first method used to supply bacteria to soils that need them is, quite naturally, to transfer soil known to contain the proper bacteria to the field to be inoculated. If a legume has been successfully grown on a soil and has shown abundant nodule formation, that soil is satisfactory for this method of inoculation.

While the nodule bacteria belong to the same species and are all called **Bacillus radicola**, there are well defined strains or varieties especially adapted for certain legumes and it is more or less difficult for these special strains to adapt themselves to other legumes. In other words, certain varieties of the bacteria grow with a particular legume and will enter the roots of that legume only and no other.

One exception to this statement must be made, for it is now known that the bacteria for the nodules on sweet clover roots will inoculate alfalfa plants and vice versa.

CROSS INOCULATION NOT SUCCESSFUL.

Thus, to secure inoculation, for a particular legume, soil from a field where that legume has previously been successfully cultivated **must** be employed; no cross inoculation is possible between various legumes, such as clover and beans for example. The exception to this statement, as is noted above, consists in the fact that **soil from a sweet clover field will inoculate for alfalfa.**

THE VALUE OF THE SOIL TRANSFER METHOD.

The use of soil for inoculation has always proved of considerable value. Early experiments in Germany showed that crops are increased by inoculation and they have been very largely borne out in this country. While in most cases such crops as clovers, peas, and beans grow successfully without inoculation, others like alfalfa and soybeans make very little growth when the necessary bacteria are not supplied. When soil from a field where inoculated crops of these legumes have grown is spread uniformly over the area to be inoculated no difficulty is experienced in securing good crops. Failure to secure inoculation by the use of soil is very rare, provided care is taken to obtain well inoculated soil.

It will be shown later, however, that other soil conditions must be favorable and climatic conditions must be satisfactory or any kind of inoculation will fail to accomplish results.

If soil and climatic conditions are favorable and well inoculated soil is employed, there can be no doubt but that it will be successful.

OBJECTIONS TO THE SOIL TRANSFER METHOD

Certain objections to the use of soil for inoculation have been offered from time to time. The first of these is that it is expensive if the large quantity of soil needed must be shipped from a great distance. Then there is the danger of transferring certain plant diseases, such as "leaf blight," or the "wilt" of cowpeas, which has been known to occur in the south. Objectionable weed seeds may also be transferred as, for example, seeds of Johnson grass, which has caused much trouble to southern farmers, particularly in Mississippi.

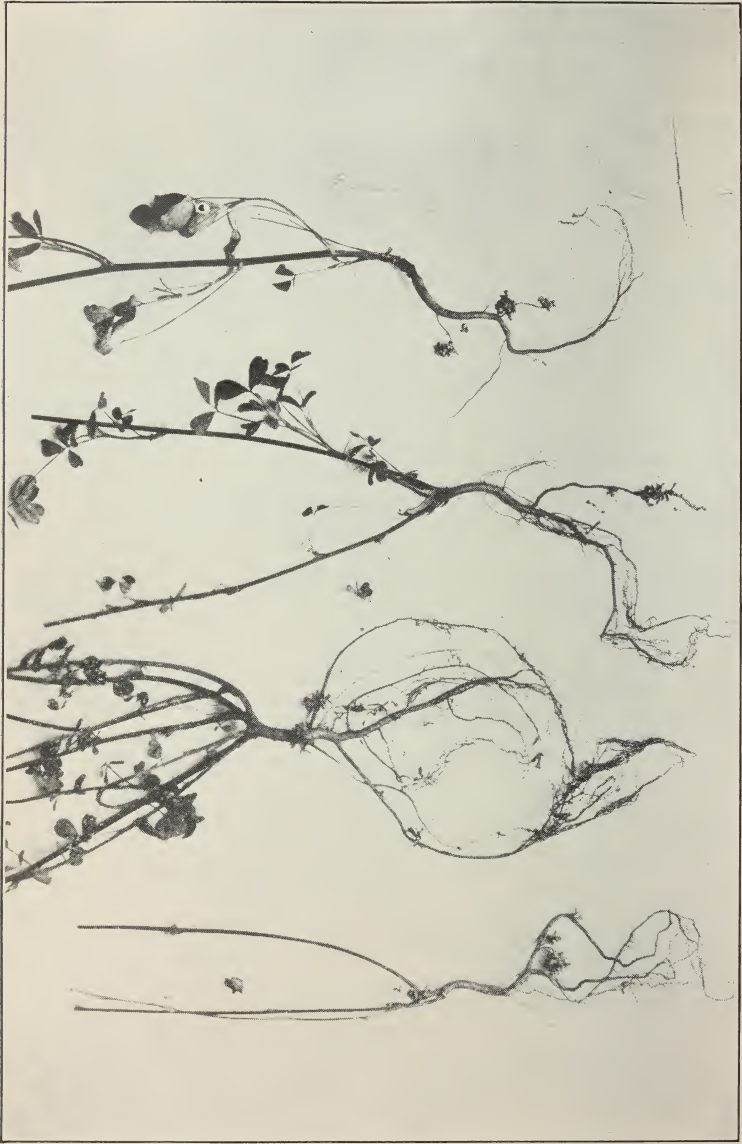
While undoubtedly there have been instances of such transfer of diseases and weed seeds, the dangers from the use of soil for inoculation have been largely overrated to make it easier to sell commercial cultures. If the soil used comes from a field where a **successful, healthy** crop of the particular legume has been grown, with **no objectionable weeds present and no plant diseases** evident, these objections are eliminated. There still remains the objection to soil because of its bulkiness and the cost of transportation. This in many cases cannot be overcome when the soil can not be secured in the surrounding territory.

PURE CULTURES.

The idea of using pure cultures for inoculation is not new. It originated soon after the discovery of the relations between bacteria and legumes. Pure cultures of nodule bacteria were obtained with little difficulty from the nodules of legumes. These grew readily on certain liquid and solid substances which contained the necessary food and it was suggested that the seed of legumes be inoculated with liquid media containing a vigorous growth of bacteria.



Alfalfa Inoculated With Sweet Clover Bacteria.



Sweet Clover Inoculated With Alfalfa Bacteria.

In 1895 the commercial preparation of pure cultures for seventeen legumes was begun in Germany and they were put on the market. These cultures consisted of bottles of nourishing jelly on which the particular bacteria were growing. The directions called for dissolving the contents of the bottle in lukewarm water, moistening the seed with that and drying the seed in a cool place before planting. This Nitragin was quite widely tested, both abroad and in this country, and was expected to revolutionize the method of soil inoculation, but the results were very disappointing and the commercial preparation was soon discontinued.

The United States Department of Agriculture then undertook the problem and prepared so-called "cotton cultures" which consisted in a growth of bacteria dried on cotton. The cultures were sent out for use with a package of sugar and salt. The latter were dissolved in water, and when the cotton was placed in the solution, the bacteria multiplied and a material suitable for inoculating the seed was obtained. These cultures were a failure also, due to the fact that the drying of the bacteria on the cotton killed many and weakened others so that they were of no value.

DIFFICULTIES IN THE PREPARATION OF PURE CULTURES.

The difficulty with most pure cultures is that when bacteria are grown in the laboratory on artificial media, they lose what is known as their **physiological efficiency**, that is, they become weakened and in that condition are unable to force an entrance into the roots of the plants.

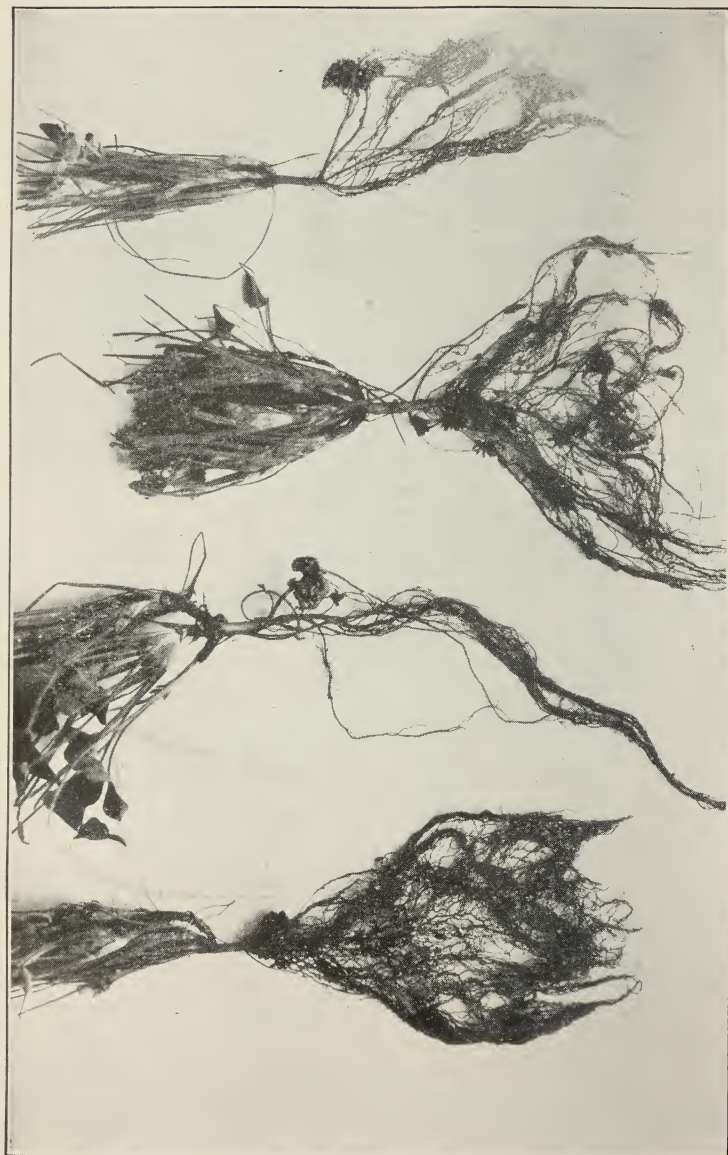
In this connection it may be said that legumes resist to a certain extent the entrance of bacteria into their roots. If the bacteria are weak, they are kept out unless the plants are also very weak. The stronger and more vigorous the plants, the stronger must the bacteria be to force their way in. Thus the effects of inoculation are always more clearly shown on legumes growing in a nitrogen-poor soil, not only because without the inoculation the crop would be small, but also because the crop is weaker and hence the roots are more easily entered by bacteria. The nodule bacteria become weak when grown in a medium containing an abundance of nitrogen, for in such a case they are not obliged to draw upon the nitrogen of the atmosphere for support. Thus in soils very rich in nitrogen, the bacteria gradually lose their power to fix the nitrogen from the air. For this reason pure cultures for inoculation are grown on nitrogen free media.

NEW METHODS OF PREPARING CULTURES.

Recently bacteria have been bred to a high state of efficiency by growing them on such nitrogen-free media and then on the roots of legumes in the laboratory. This has led to the production of pure cultures which are much more promising than any previously prepared.

Cultures of highly vigorous organisms prepared by a commercial concern have been tested somewhat extensively and in many cases have given quite satisfactory results. **Not in all cases**, however, was inoculation accomplished and frequently **soil proved better**. Some failures occurred when all precautions were taken to make soil conditions satisfactory, and when the weather conditions could not be held responsible; hence the difficulty must be charged to the cultures.

Another preparation has recently been placed on the market which gives indications of considerable value. It has not been tested enough yet to permit of positive statements, but the cultures undoubtedly contain vigorous organisms, and the preparation is well



Young Crimson Clover Plants With Large Nodules.

calculated to preserve the bacteria in an efficient form. It is reasonable to expect that the successes which have been reported in certain sections from the use of their cultures should be repeated.

TESTS NOT CONCLUSIVE.

Experiments carried on during the last year at the Iowa Agricultural Experiment station to test pure cultures on cowpeas and soybeans do not permit of definite conclusions, owing to an early frost which stopped the growth of the plants.

Before the frost, the inoculated plots were much greener and more healthy and had an abundance of nodules. At the time of the frost, they were still in a vigorous growing condition while the plants on the uninoculated plots were mature.

While the weights of the crops obtained on these plots did not show any benefits from the inoculation, the nitrogen content of the inoculated plants was much greater than that of the uninoculated. A longer season of growth would probably have given larger yields also for the inoculated plots. Further tests of this material and comparisons of its value with that of soil should be made. If such tests show superior or equal value, then the pure cultures should be advocated to avoid the labor and expense involved in obtaining soil for inoculation.

SOIL TRANSFER STILL RECOMMENDED.

Until that time, however, in view of the uncertainty attendant upon the use of pure cultures, soil transfer should still be recommended.

Precautions to be observed. The precautions already noted with regard to obtaining soil should be kept in mind and fields where plant diseases or objectionable weeds are prevalent should be carefully avoided. Care should be taken also that the soil be obtained from fields where the particular legume has been grown successfully with abundant inoculation, except that in the case of alfalfa, soil from a sweet clover field may be used.

Amount of Soil to Use. Three hundred to five hundred pounds of soil per acre should be secured and thoroughly distributed on the field to be seeded, and disked in. As has already been stated, under satisfactory soil and climatic conditions, if well inoculated soil is obtained with the above precautions the success of the inoculation is practically assured.

WHEN INOCULATION IS NECESSARY

Since the best results with legumes can be obtained only when the proper bacteria are associated with the plants, and since the necessary nodule bacteria are not present in all soils, it is evident that inoculation is essential when a legume is to be grown on a poor soil which has never borne one previously.

Inoculation is necessary also if a legume possessing no nodules on its roots has been grown in the soil. In some cases on apparently quite fertile soils, legumes will make but a poor growth in the absence of nodules.

If a legume grown previously has made poor growth, even though nodules have been shown on its roots, the soil should be inoculated. Experience has shown that it may take several crops of the same legume, showing increasing numbers of nodules on the roots, before inoculation will be extensive enough.

Inoculation should also be performed in cases where another legume has been grown on the field except, as has been noted, in the case of alfalfa and sweet clover.

Occasionally soils upon which a legume has previously been successfully grown will not produce an inoculated crop of the legume. This may be due to a loss of vigor in the bacteria left in the soil and the introduction of vigorous forms will insure inoculation.

It is practically impossible to determine this condition in a soil and experimental inoculation is the only way to find out the need of a crop in this direction. Hence, if a legume was grown successfully inoculated, several years before, the soil should be inoculated again to insure success.

WHEN INOCULATION IS UNNECESSARY.

Inoculation is unnecessary where average yields of the particular leguminous crops are being obtained and the roots are well inoculated. Under those conditions, it is practically certain that the proper bacteria are present in sufficient numbers, and in a high state of vigor.

CONDITIONS NECESSARY FOR SUCCESSFUL INOCULATION

Contrary to a somewhat prevalent belief, the inoculation of a legume is not all that is necessary to insure the success of a crop. If other important soil conditions are not carefully observed, inoculation will be entirely unsuccessful.

Selecting the Seed. In the first place, the seed should be very carefully selected, as poor seed will cause a poor crop in spite of the best of soil conditions, the presence of vigorous bacteria and the best climatic conditions.

Preparing the Seed Bed. Then the seed bed should be prepared very carefully to insure the best mechanical conditions of the soil.

Cultural studies of the bacteria have shown them to be very closely dependent on the air supply, especially with reference to nitrogen. Deprived of the proper amount of air, the organisms soon die. Thorough cultivation puts an abundance of air into the soil for the growth of the bacteria and therefore should be practiced.

Regulating Water Content of Soil. Cultivation also conserves the moisture content of the soil by preventing undue loss through evaporation. Experience has shown that water in the proper amount is essential for nodule formation. Increasing the moisture content of a soil up to that amount increases the number of nodules formed. More than enough water, however, will check the development of nodules by shutting out the air. Thus soils which are very wet should be thoroughly drained before attempting to grow legumes on them.

Eliminating Objectionable Weeds. Thorough cultivation before seeding is also an important factor in killing out weeds which may later prevent a good stand of the legume.

Correcting Acidity. The relative acidity ("sourness") or alkalinity, or reaction, of the soil, should be carefully determined before seeding to a legume. All legumes, and particularly alfalfa and clover, are sensitive to acid conditions in the soil. If the litmus paper test shows the soil to be acid, even though only slightly so, applications of ground limestone should be made to the extent of 2000-6000 lbs. per acre, depending on the degree of acidity.



Young Cowpea Plants With Characteristic Nodules.

To make the litmus paper test, secure a small sample of soil free from roots and grass and put it in a clear water glass. Insert two strips of blue litmus paper in the soil so that they are half covered. Then add pure water very carefully until the soil is thoroughly saturated. After the test has stood for several minutes, remove the paper and rinse thoroughly. If that portion of it which was in contact with the soil has become red then the soil is acid and would be benefited by liming. The litmus paper may be bought at almost any drug store.

Supplementing Plant Food Deficiencies. Again, if the soils are deficient in phosphorus or potassium, the best crop yields of legumes cannot be obtained any more than is the case with other crops. In such cases, phosphatic and potassic fertilizers must be resorted to in order to remedy the deficiency.

Choosing the Legume. There is one other point to be considered in the growth of legumes and that is the selection of a legume for a particular locality.

Experience has shown that certain legumes are well adapted for certain climates while others would prove a complete failure under the same conditions. Consequently, the legumes which are known to be adapted to certain climatic conditions should be chosen, for the greatest care in every detail will not accomplish the successful production of any legume not adapted to the locality.

CONCLUSION.

If, then, good seed is secured, the seed bed is thoroughly prepared with the elimination of weeds which might prove a nuisance, proper regulation of the water content is provided, the absence of acid conditions is assured and the necessary phosphorus and potassium compounds are present in the soil, inoculation should prove of value in most cases. It will be unnecessary, however, to inoculate in cases where the legume has previously been successfully grown.

In short, in preparing for a leguminous crop the farmer should use all the precautions which the majority are now employing for the growth of all crops. Then if thorough inoculation is performed by the use of soil from a carefully examined source, climatic conditions being favorable, optimum yields should be obtained.

EXPERIMENTS SUGGESTED.

It is highly desirable that the pure cultures prepared for soil inoculation should be tested at various localities and any farmer who contemplates growing legumes for which inoculation will be necessary, will perform a service to the state if he will arrange to test the efficiency of some pure cultures.

This may be accomplished by dividing the field into sections, as uniformly located as possible, inoculating one section with soil and planting the other with seed inoculated as directed with the pure culture. The weights of the crops should be obtained and the relative efficiency of the two methods of inoculation ascertained.

Such co-operation on the part of the farmers may assist materially in the adoption of a pure culture method for inoculation which will simplify the difficulties connected with the growth of legumes very appreciably.

FARM MANURES

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FARM MANURES

By P. E. Brown

More than 2,000 years ago it was known that the application of farm manures to soils increased the yields of various crops. Since then the need of putting back into the land in this way some of the fertility taken out by crops has become more and more evident. It was not, however, until the middle of the last century that much of the mystery as to why the action of manures was beneficial was cleared up by the brilliant researches of Liebig.

The conclusions arrived at by Liebig and which, somewhat modified by later experiments, are still the essential principles of modern agriculture were:

1. "A soil can be termed fertile only when it contains *all the materials requisite for the nutrition of plants*, in the required quantity and in *the proper form*."

2. "With every crop a portion of these ingredients is removed. A part of this portion is again added from the inexhaustible store of the atmosphere, another part, however, is *lost forever if not replaced by man*."

3. "The fertility of the soil remains unchanged if all the ingredients of a crop are given back to the land. Such a restitution is effected by *manure*."

4. "The manure produced in the course of husbandry is not sufficient to permanently maintain the fertility of a farm; it lacks the constituents which are annually exported in the shape of grain, hay, milk and live stock."

Certain elements must be present in the soil for the growth of plants. They are called plant food constituents. Many of these are present in such large amounts that ordinary crop production can not exhaust them. Other elements, namely,—nitrogen, phosphorus and potassium, are often lacking and consequently these materials must be added to maintain the fertility of the soil. If the produce of the farm, such as milk, grain, hay, etc., is sold, then these essential plant foods will be removed from the soil in amounts varying with the kind and quantity of the produce sold. If there is no return of these elements, the soils will become poor and finally refuse to grow crops.

A manure has been defined as a material which furnishes any of these essential plant food constituents. Farm manures, consisting of the excreta of farm animals mixed with litter, and other refuse, contain plant food constituents derived from the vegetable food that the animals eat.

If farm produce is fed to animals on the farm where it is grown and

their manure is returned to the soil, then loss due to cropping is decreased and the fertility of the soil is maintained for a longer time. Furthermore, as has been said, "if the business of stock feeding is carried to the point where feed is purchased in addition to that grown on the farm, a considerable addition may in this way be made to the fertility of the farm at an almost nominal cost since it is assured that feed will not be bought unless its feeding value will at least pay the cost."

This statement is not absolutely true for all circumstances, however. Even though farm manure contains more or less of all the essential constituents in the food, if it is stored for any length of time, even under the best possible conditions, some loss is certain to occur. If the manure is not well cared for and properly stored, only a very small portion of the plant food taken out of the soil by the crops will be returned. The farmer who is content to keep his manure unprotected, perhaps on a hillside on the banks of a stream, is allowing his soil to become depleted very rapidly in crop producing power. Furthermore, if feed is purchased and the manure obtained is applied to the soil to increase the fertility of one farm, some other farm will be depleted in fertility to just that extent. Farm manures, therefore, play an important, even though not all sufficient, part in the maintenance of soil fertility.

COMPOSITION OF FARM MANURES

It is natural that the composition of farm manures should vary greatly. The manure may contain the excreta of several different kinds of animals or of only one kind; it may contain various materials which have been used for litter, and still other factors may vary. It is, therefore, almost impossible to state the actual plant food content of farm manure. However, a study of all the facts bearing on the subject has led to this statement of the average composition of farm manure:

One ton of farm manure contains: 10 lbs. of potash (8.3 lbs. K.), 5 lbs. of phosphoric acid (2.2 lbs. P.), 10 lbs. of nitrogen.

The factors which influence the composition of farm manure may be grouped into three classes. First, those which relate to the excrement produced by the animals; second, those which refer to the litter employed, and third, those which deal with methods of treatment of the manure after it is produced.

ANIMAL EXCREMENT

The excrement of all animals is made up of two portions, solid and liquid. The solid excrement is composed mainly of the undigested portion of the food. It contains the original constituents in a moist, softened condition and hence may be more easily decomposed than when in the food before it was eaten. The liquid portion is mostly water but contains also the digested portions of the food and the waste product from the digestive action.

The liquid excreta is much richer than the solid portion. It contains $\frac{2}{3}$ of the total nitrogen and $\frac{4}{5}$ of the total potassium of the feces. On the

other hand, practically all of the phosphorus excreted is in the dung. Not only does the urine contain more of the valuable constituents but they are in an available, soluble form. The losses which occur in manure due to improper storing, etc., fall upon the liquid, and therefore most valuable, portion of the manure and all schemes to prevent such loss deal with saving the liquid portion.

The relative amounts of dung and urine produced by different animals will vary with the kind of animals and the food consumed. For cows usually the total weight of the urine is twice the weight of the dung. In the case of horses and sheep the amounts of solid and liquid are about equal. With hogs, the urine is usually very abundant but the variations are so great that exact relations between the amounts of solid and liquid cannot be stated.

FACTORS INFLUENCING THE EXCRETA

Several factors exert important influences on the character of animal excreta. These are the age, treatment and condition of the animal, the kind of animal and the quality and quantity of food.

Age, Treatment and Condition. As they feed, young animals keep much greater amounts of fertilizing constituents in their bodies than mature animals which are neither gaining nor losing in weight. Nitrogen, phosphorus and potassium are used by the young growing animals in building up new bones, muscles and other tissues and hence fail to appear in any considerable quantity in the manure. The manure from mature animals which have their growth will contain much more of these valuable constituents. It has been estimated that nearly all of the fertilizer constituents (90 to 95%) of the food may appear in the excreta of mature animals. Young animals, on the other hand, may retain as much as 50% of their food in their bodies. The excreta of milch cows contains only about 75% of the fertilizer constituents in their food, and the excreta of sheep contains a similar amount.

The condition of the animal also determines the character of the excreta. If it is in poor condition, it will take up a very large portion of the valuable matter from its food but if it is in a healthy state and mature and is merely getting fat, very little loss of fertilizer constituents from the food is noticed. Fat contains none of the valuable constituents and hence they are not removed from the food by fattening animals but pass on into the excreta.

The Kind of Animal. The variation in the composition and in the amount of manure produced by different farm animals is very great. In general it may be said that animals producing the smaller amounts of manure yield a richer product. For instance, sheep produce the smallest amount of excreta per 1,000 lbs. live weight but their manure is of the greatest value. On the other hand, cows produce the largest amount of manure but it is of the poorest quality. In the case of hogs, however, we find that they produce a large amount of manure which is equal in value to that of sheep.

These variations are due largely to the feeding habits of the animals, especially with regard to water.

Horse manure contains less water than the others and is therefore known as a "hot" manure because the decomposition processes going on in it are very vigorous and create a high temperature. There is danger of loss of valuable constituents from horse manure if it is not kept moist. This is particularly true of ammonia, the odor of which may often be noticed in the air of stables in which the manure has been allowed to dry out.

Cow manure, on the other hand contains a large amount of water and hence is called a "cold" manure as the air is largely excluded by the moisture and decomposition processes are very slow. The danger here of a loss of volatile constituents is not nearly so great as in the case of the horse manure.

Sheep manure is one of the most valuable of farm manures. It is drier and richer in nitrogen than cow manure, but not so dry as horse manure. The decomposition processes, therefore, proceed less rapidly than in the case of the latter material but more rapidly than in the case of the former.

Hog manure is also valuable but it is exceedingly variable in composition. There is a large amount of water present in this manure and decomposition processes hence are somewhat slow.

Poultry manure is the richest manure produced on the farm. It contains very little water but is rich in nitrogen. It decomposes very quickly therefore and the danger of loss of its volatile constituents is very great.

The Quality and Quantity of Food. The composition of the excreta of farm animals is influenced more by the quality and quantity of their food than by any other factor. The plant food constituents of the food eaten are found more or less completely in the feces, varying with the age, treatment and kind of animals involved. There can be no gain in valuable constituents in the change of food into manure, but they undergo a physical change in the animal body which put them into a more usable form. If the feed is poor in plant food, the manure will be correspondingly poor. If the animals are fed on highly concentrated feeds, the excreta will be rich.

The plant food value of common animal feeds has been calculated and is exceedingly variable. It ranges from \$19.80 per ton in the case of cotton seed meal to \$.90 per ton for turnips. In general, then, it may be said that animals fed on concentrated feeds like cottonseed meal, linseed meal, gluten meal, etc., yield the richest manure; those fed on alfalfa hay, red clover hay, etc., the next richest; those fed on cereals (corn, oats, etc.), the next most valuable; and finally those fed on root crops like turnips yield the poorest manure.

The amount of nitrogen present in an animal's food is the most important consideration in determining the value of its manure. Nitrogen is the most important fertilizer element of the manure and the one which is most likely to be lost. The more nitrogen in the food, therefore, the greater the value of the excreta. With increasing amounts of nitrogen in the food, more urine is excreted, more litter is required, and the increased bulk of

the manure makes up for inferior quality. Very rich feeds, or large quantities, increase the value of the feces also, because such feeds are not wholly digested and used by the animal.

The amount of water drunk is likewise important in determining the value of manure. As it varies with different animals, of different ages, etc., the composition of the urine is very largely affected. The percentage of nitrogen compounds in the urine will vary with the amount of urine. The more water drunk, the poorer is the composition of the urine, but this is compensated for in the fact that the weaker the urine, the greater the quantity produced.

LITTER

Farm manures consist of mixtures of solid and liquid excreta with litter. The character and composition of the manures is therefore very largely determined by the character of the material used for litter.

The chief purpose of litter is to absorb and hold the valuable liquid excrement of animals and to keep the animals clean and comfortable. It gives value to the manure in other ways also. By increasing the quantity of the manure it helps distribution. Because of its content of plant food and other qualities it improves the physical and chemical character of the manure. Finally, litter regulates the decomposition of manure, not only by governing the admission of air, but also by actually adding bacteria.

The value of different litter materials is determined very largely by their absorbing power and their content of plant food. The prevention of the loss of the urine is a most important function of litter, for, as already noted, that is the most valuable portion of the animal excreta.

Straw is perhaps the most common material used for litter. It is a very good absorbent and possesses some manurial value. It contains 16 lbs. of nitrogen, 1.8 lbs. phosphorus and 21.6 lbs. of potassium per ton and hence increases the amount of these constituents in the manure. The straws of different grains will vary somewhat in composition and toughness but their value as litter is about the same.

Hay, both salt and fresh, may be used for litter. The former is slow to decay and the salt reduces the rate of decomposition of the manure. Neither material possesses as good absorptive power as straw and although the plant food content of fresh hay is somewhat greater than that of straw, this advantage is insufficient to warrant its use instead of straw.

Peat or peat moss are sometimes used for litter and they are very absorptive. Peat moss will absorb ten times its own weight of water while straw will absorb only three times its weight of water. They contain very little plant food and are not in very common use.

Sawdust has value as an absorbent and but little as plant food. It usually gives the manure a good mechanical condition but sometimes, as when used with horse manure, it makes the manure too open and encourages loss of valuable constituents. Sawdust is used quite frequently in city stables.

Dried leaves, soil, tanners' refuse and other materials possessing more or less absorptive power are occasionally employed, but their use can hardly be recommended either on grounds of economy or expediency.

METHOD OF TREATING MANURES

The composition of farm manures depends not only on the character of the solid and liquid excreta and the litter used but also on the way in which the manure is handled and stored after it is produced. Under certain conditions the fertilizers in the food go almost entirely into the manure. There is always some loss of valuable matter from the manure, however, if it is stored before being used. The most careful methods which it is possible to employ limit that loss to 15% of the valuable constituents. Lack of care in keeping manures will increase this loss at least to 35% and if, as is often the case, all the valuable urine is allowed to leach out of the manure pile and run away in a stream, there is a 70 to 80% loss.

The actual money loss due to improper storing of manure has been variously estimated. Lipman assumes a 20% loss from the manure of horses and mules. Placing the value of the manure produced by all these animals in the United States at \$700,000,000 a year which is a conservative estimate, there may be a loss of \$140,000,000 a year due to careless storage of manure. Others have placed the estimated loss from the manure of all farm animals at 33⅓% and Roberts calculated from that estimate, that the average annual loss for each farm in the United States would amount to \$83.33. Many farms suffer losses to a much greater extent and others to a less degree but it is evident from these figures that all possible care should be taken to prevent losses.

Roberts says, "The new idea that the manure should be as carefully preserved from unnecessary waste as any other product of the farm, is hard to put in practice after having for 40 years stored the farmyard manure under the eaves upon a steep hillside which forms one border of a running brook."

LOSSES OF FARM MANURE

These heavy losses from farm manures may come through the escape by leaching of liquid and other valuable constituents or by the fermentation of the manure and the loss of nitrogen by volatilization, or evaporation.

Leaching of Farm Manure. Inasmuch as the liquid portion of the feces contains the greater part of the valuable constituents, particularly nitrogen, when that part escapes much of the fertilizer value of the manure is lost.

To prevent this, in the first place litter of good absorbent power should be used. Furthermore, manure should be sheltered. When, as is so often the case, manure is allowed to remain for months unprotected from sun and rain, the loss, not only of nitrogen but also of potassium and phosphorus, may be very great. It has been estimated that in six months, 60 to 70% of the plant food present may disappear in this way. In general, it is safe to say that about one-half of the plant food value of manure may be lost by such careless storing or rather lack of storing. This loss does not fall

on the liquid portion only but also upon the solid, which in the course of several months may lose one-half of the nitrogen, phosphorus and potassium which it contained.

FERMENTATION OF FARM MANURE

Every farmer has seen the changes which manures undergo on standing. They shrink in bulk, become dark in color, the temperature rises and the composition is completely altered. Some of the plant food is lost entirely by being volatilized and passing out into the surrounding air and the remainder is changed into a more available form. These changes are the result of the action of various microorganisms notably bacteria and molds.

BACTERIA IN MANURE

Containing as it does much plant food and a large amount of organic matter, it is not surprising that manure is the home of numerous bacteria. The number of such organisms will vary considerably, depending on the physical and chemical character of the manure, the method of treatment, etc. In general it may be said that manure may contain from 7,000,000 to 375,000,000 bacteria per gram (1-30 oz.). On the average farm manures probably contain about 80,000,000 organisms per gram. Most of these organisms occur in the solid excreta which has been found to contain 18 to 40 billion bacteria per gram. The urine is practically sterile and the litter usually contains comparatively small numbers.

Some idea of the bacterial matter in manure may be given by the estimate that 9 to 20% of the dry weight of cow manure consists of bacterial substance.

Furthermore there is a great multiplication of bacteria on standing and in a few weeks the number present will be much larger than at first. After a longer or shorter interval, however, depending on the physical and chemical composition of the manure, this increase in number of bacteria will cease and a decrease will occur. These facts may be easily understood when we recall that the manure at first contains a large amount of available food which causes a great multiplication of bacteria. As this available food decreases there is not enough to support the increased number of organisms and many of these therefore die.

THE CLASSES OF BACTERIA IN MANURE

The bacteria present in manure may be divided into two classes; the *aerobes*, which require air, and the *anaerobes* which require absence of air for their growth. Whether there are more bacteria of one or the other of these classes will depend very largely upon the physical condition of the manure which will vary with decomposition.

The fermentations brought about by these two classes of bacteria are quite different, particularly with regard to the final products. Both classes of action may occur together, the aerobic bacteria working at the surface of the manure pile and the anaerobic in the inside. If the manure is loosely stored, then the aerobes are most active; if it is packed lightly

the anaerobes will be most active. In the decomposition or rotting processes brought about by these bacteria, the various constituents of the manure are attacked and changed into more available or simpler forms. Thus the *proteins* or complex nitrogenous compounds, are changed through various stages into ammonia. The non-nitrogenous compounds, like cellulose or other carbohydrates, are changed finally into carbon dioxide gas, hydrogen, water, etc. The complex potassium and phosphorus compounds from the food are acted upon by the acids and carbon dioxide in decomposition and rendered available.

The losses from manure brought about by bacteria fall mainly on the nitrogen, the most valuable constituent.

Loss of Ammonia Gas

If the aerobic bacteria are most active much ammonia gas (NH_3) will be formed and this will be lost into the air. This loss of ammonia gas is particularly apt to occur from the urine. The loss of ammonia in this way from urine is evidenced by and may be detected in the odor of ammonia in stables. The nitrogen compounds of the solid excreta may also be lost as ammonia gas, if plenty of air is present in the manure pile.

Loss of ammonia from the liquid manure may be checked by the use of absorbent litter which holds the liquid and prevents its decomposition. Loss from the solid portion may be prevented as will be shown later, by keeping the manure moist and protecting it from the action of sun and rain.

Loss of Nitrogen Gas

Nitrogen gas will also be lost from manure if aerobic bacteria are allowed to work away undisturbed. They will change ammonium compounds formed in the decomposition of proteins still further to nitrogen gas which will then pass off into the air. This general loss of nitrogen from manure loosely piled is the main cause of its decrease in value.

CHANGE OF AVAILABLE NITROGEN INTO UNAVAILABLE

There is another process which should be mentioned here because it concerns a loss of soluble nitrogen in the manure through its change into insoluble nitrogen. The change is brought about by bacteria. They take up simple nitrogenous materials and store them in their bodies as complex substances. This of course does not involve a loss of nitrogen but checks the loss of nitrogen by keeping in the manure ammonia and nitrates which might otherwise be lost by passing into the air or by leaching.

LESS LOSS UNDER ANAEROBIC CONDITIONS

When manure is packed and kept moist, air is very largely kept out, the anaerobic bacteria are favored and the changes occurring are quite different. There is a much smaller production of simple compounds like ammonia. The changes in the complex materials are checked by the lack of air and while some losses occur they are very small compared with those brought about under aerobic conditions. The comparative losses in manure under aerobic and anaerobic conditions have been well shown. Careful experiments demonstrated that manure loosely stored, with abundant

air present, in twenty-one weeks lost 53% of its organic matter and 34% of its nitrogen while compacted manure lost in the same length of time only 28% of its organic matter and 15% of its nitrogen.

It is evident, therefore, that anaerobic activities are much less wasteful of the nitrogen in manure than are aerobic processes. All methods of storing of manure which tend to keep out air are beneficial in that they tend to reduce the loss of nitrogen.

METHODS OF PREVENTING LOSSES FROM MANURE

The losses from farm manures may be prevented or at least reduced by chemical or mechanical means.

CHEMICAL METHODS

The mixing of various materials with manure has been advocated from time to time to prevent the loss of valuable constituents. Among these may be mentioned land plaster or gypsum, kainit, superphosphate, phosphate rock or "floats," sulphuric acid, salt, lime, etc. While in some cases some of these substances have reduced the loss of certain constituents by chemical action or by the restriction of fermentation, the disadvantages of their use outweigh the advantages and they are not recommended for general farm purposes.

MECHANICAL METHODS

Mechanical means of caring for manure have received much attention and the value of various methods have been carefully compared.

In the first place the litter is one of the most important means of preventing loss and very absorbent materials should be used to hold the valuable liquids. Water tight floors and gutters in the stables also lessen the danger of loss of the liquid manure.

The loss of nitrogen into the air may be reduced by checking the fermentation processes in the manure. As has been noted already, if the manure is kept packed and moist, the aerobic bacteria are restricted and the anaerobic encouraged and the danger of loss of nitrogen becomes much less.

STORING MANURES

There are several methods of storing manure to prevent losses due to temperature, to the weather and to leaching and among these are the use of pits, covered yards, deep stalls, and composting.

Pits are sometimes used to keep the solid and liquid excreta together and thus prevent loss by leaching and by aerobic bacterial activities. One difficulty is encountered here in keeping the upper part of the manure wet enough as the liquid of course collects in the bottom of the pit. In France this difficulty is overcome by allowing the liquid portion to drain into a separate pit and then pumping it over the solid mass from time to time.

Covered yards consist in well roofed sheds with or without sides and should have water tight floors. The manure is thus protected from rain and leaching and from the alternate wetting and drying out which leads to destructive fermentation processes. The moisture content of the manure



Corn Grown on a Plot of Ground not treated with manure

must be regulated and it must be kept compact. Frequently the animals are allowed to run in such covered yards and in that way compactness is secured and the loss is slight.

Deep stalls are much used in Europe. The method consists in allowing the litter and excreta to accumulate under the feet of the animals. It becomes very compact and very little loss can occur. The method is considered objectionable in this country for sanitary reasons, particularly with dairy animals.

Composting. Various methods of composting manure may be employed. They all consist in storing it in alternate layers with some absorbent material, keeping the pile moist and well covered and turning it over occasionally. Soil, peat or muck, or well-rotted manure may be employed as the absorbent and if proper care is taken to keep the moisture right very little loss can occur.



Corn Grown on a Plot of Ground treated with Manure

THE VALUE OF FARM MANURES

The value of farm manures has always been recognized and for many years they were the only fertilizing material of any importance.

Chemical. In the first place farm manures add a considerable amount of plant food to the soil, as has been shown already. Thus there is returned to the soil at least a portion of the constituents which are taken out by the crops. Furthermore when manure is properly stored they are returned in a form available for plant nourishment.

Physical. One ton of manure adds on the average about 425 lbs. of organic matter to the soil. This organic matter not only acts in improving the physical character of the soil with regard to waterholding power, warmth, aeration, etc., but when it decays it leads to the production of larger quantities of available plant food *from the soil itself*.

Bacteriological. Manure contains an enormous number of bacteria.

Consequently when it is applied to the soil the bacterial content of the soil is increased and beneficial bacterial activities are encouraged. Manured soils have shown greater production of nitrogen available for plants than have unmanured soils and this is due to the greater bacterial activities.

The value of farm manures therefore as a means of increasing crop production depends on the improved chemical, physical and bacteriological condition of the soil attendant upon its use. Furthermore the effect of applications of farm manure is not exhausted in one season but may be shown in the crop yields for many succeeding years.

It must be emphasized here again that while applications of farm manure do not restore to the soil *all* the fertility removed by crops which have been fed to the animals producing the manure, they do restore a large portion of the valuable constituents and prevent as rapid a depletion of the soil as would otherwise occur. Again if feeds are purchased for live stock and the manure produced is applied to the soil, the loss of fertility from the soil may be reduced to a minimum.

The value of applications of farm manures to Iowa soils cannot be doubted in the light of the results obtained at the Iowa Agricultural Experiment Station. The advantages gained by their use on the loose soils are well demonstrated by the results given in Bulletin 95 of the experiment station and the accompanying plates which are reproduced from that bulletin.

Recent, and still unpublished data secured on the experimental plots of the station at Ames, on Wisconsin drift soil, also show beyond question the increased yields of corn, oats and clover obtained when manure is applied once in the rotation.

THE USE OF FARM MANURES

Farm manures may be applied to the soil either in a fresh or a well rotted condition.

FRESH OR ROTTED MANURES

The application of fresh manure has some advantages, among which may be mentioned the smaller loss of plant food by leaching and fermentation and the utilization of all the valuable constituents present. The fermentation processes occur in the soil and consequently there is greater effect on the plant food in the soil itself. The physical effects of fresh manure may also be greater than those of rotted manure, particularly in opening up heavy soils. Fresh manure has also been shown to favor especially the growing of stems and leaves and hence may be of considerable advantage to certain crops.

There are some disadvantages, however, in the use of fresh manure which should be mentioned. When fresh manure is applied to light, sandy soils it may dry out the soil too much and prevent the best decomposition of the organic matter present and it may lessen the water holding power of the soil. Many crops may be affected injuriously by fresh manure. It

sometimes causes too rapid production of plant food and that may affect the plants. Furthermore, certain crops may be reduced by the over production of stems and leaves which fresh manure encourages.

Well rotted manure is a better balanced manure, the phosphorus and potassium being in a more available form and in a larger proportion and the nitrogen in a less available form. It possesses the advantages also of convenience in handling, more uniform action, and no danger of injury to light soils.

In general, the character of the soil and the nature of the crop to be grown will determine the relative advantages of fresh and well rotted manure for particular conditions. Fresh manure will prove of considerable advantage, for instance on heavy soils, but should be used carefully on light soils.

On Iowa soils there is a little danger from the use of fresh manure if it is applied about as it is produced during the fall and winter and thoroughly mixed with the soil before seeding. If so used there is the least danger of loss of valuable constituents, as these are leached into the soil and retained there. Moreover, the effect on the crop is not at all injurious.

THE AMOUNT TO APPLY

No fixed recommendation can be made as to how much manure to apply, but in general 5 tons per acre is a light application, 10 tons moderate, and 20 tons heavy. Moderate applications of manure will usually maintain the humus content of fertile soils while soils poor in humus will be benefited by heavy applications. The amount to apply will therefore be determined by the character of the soil and the crop to be grown.

DISTRIBUTION

Manure may be distributed in three ways, by broadcasting, by distributing in heaps and then spreading and by drilling in with the seed. Broadcasting is perhaps the most common practice and it scatters the manure uniformly over the land at the least expense. The manure spreader is generally used for this method. When manure is distributed in heaps and then spread by hand, much handling is required and if it is allowed to remain in the heaps for any length of time, the spots under the piles receive the benefit of all the leaching. Drilling the manure in with the seed is occasionally practiced for forcing some plants and has an important effect. Fresh manure cannot be used for this purpose.

TIME OF APPLICATION

Manure may be spread on the soil as rapidly as it is produced during the fall and winter preceding spring plowing or it may be stored and spread just before plowing. If it is spread as produced there will be no loss in storing and it is put on the land at convenient times and with less handling than if it is stored. There is one disadvantage in the application of manure as produced. When it is spread on the soil the soluble portion leaches out into the soil and the insoluble is left; this decomposes much more

slowly when it is finally mixed with the soil than if it had decomposed with the soluble portion. Manure should, of course, not be spread as produced on soils subject to flooding or on hillsides, as the valuable portion will be washed away before it is mixed with the soil.

Furthermore, if manure is spread as produced on soils to be fall plowed and is allowed to lie on the surface of the ground during dry, hot weather, ammonia may be lost.

With these exceptions, however, it is undoubtedly the best plan to spread the manure on the soil as produced or at as short intervals as possible to avoid losses.

CONCLUSION

We have found that the composition of manure is exceedingly variable and is regulated by various factors such as the character of the animal excreta, the litter used and the care of the manure after production. The composition of the animal excreta has been shown to depend on the kind of animals producing it, the age, treatment, and condition of the animals, and the quality and quantity of their feed.

The extensive losses which farm manures incur by leaching and improper fermentations have been discussed and methods of storing to prevent such losses have been suggested.

The value of farm manures is too well known to need any further emphasis but experiments on Iowa soils have shown beyond doubt their value for increasing crops.

Finally the use of farm manures with regard to time of application, amount to apply, etc., has been briefly discussed and some suggestions offered.

If the soils of Iowa are to be maintained in a fertile condition, the farm manures *must* be carefully collected and preserved and the valuable constituents which they contain returned to the soil.

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GREEN MANURING AND SOIL FERTILITY

By P. E. Brown

Green manuring puts humus into the soil and that makes it an important farm practice, because humus is absolutely essential for the best growth of crops. Humus may be added in another way, by applying barnyard manure, but that method alone will not keep the soil from losing fertility from year to year. Even though it is saved with the utmost care, the manure produced on the farm will not return to the soil all the fertility removed by the crops. Circular No. 9, "Farm Manures," Iowa Agricultural Experiment Station, shows furthermore, that there are certain unavoidable losses in the storing of manure and that they may involve not only the valuable mineral constituents, but also the organic matter. As agriculture is now generally practiced in Iowa as well as elsewhere, the soil is being gradually worn out.

It is clear, therefore, that some other means must be employed to keep up the humus content of soils and this may be accomplished by turning under green manure crops.

THE VALUE OF GREEN MANURES

Any crops grown and plowed under green to improve the condition of the soil are called green manure crops. When such crops are used in addition to a regular rotation and occupy the land for only a part of the season, they are known as "cover" crops or "catch" crops.

The value of green manures as a means of improving soil conditions has been known for centuries and in the light of past experience it is somewhat surprising that their use is not more common now.

Green manuring is not enough in itself, of course, to keep a soil from wearing out. There are other practices that must be followed also. Crop rotation must be practiced. The amount of moisture in the soil must be regulated. Proper tillage must be employed. Steps must be taken to keep soils from becoming acid. The supply of the mineral plant foods, especially nitrogen, phosphorus and potassium, must be kept up. This may be done in the case of nitrogen by growing legumes that take nitrogen from the air. Potassium is not likely to be deficient in Iowa soils for centuries. Phosphorus must be applied as it is needed. These factors are all important in keeping a soil fertile, but not more important than green manuring.

In general, it may be said that green manures improve poor soil because of their action on the physical, chemical, and bacteriological conditions pertaining to the soil.

THE PHYSICAL EFFECTS OF GREEN MANURES

The character of a soil very largely determines the physical effects of a green manure upon it. If light, and sandy, it will be affected quite differently than if heavy and clayey. In general, however, green manures influence the moisture conditions, the temperature, the aeration, and the



Soy Beans on the Iowa Agricultural Experiment Station Plot.

sourness of soils. Through these physical effects, the chemical and bacteriological conditions are considerably altered.

MOISTURE

On light, sandy soils, green manure prevents rapid drying out, which so often occurs, by cutting down the losses of moisture due to evaporation and percolation. Green manures make the soil more compact by uniting the fine particles into larger masses, and the humus or organic matter, itself acts like a sponge in holding water. Thus by the use of green manures, sandy soils, otherwise infertile, may be made to hold enough moisture for crop production.

Green manures have the opposite effect on heavy clay soils. The organic matter opens them up, admitting air, and preventing extreme moisture conditions. It also makes them less stiff and more crumbly when dry. Thus not only is the mechanical conditions of the soil made better, but the chemical and bacteriological conditions are also much improved. Green manuring may exert certain mechanical effects on both heavy and light soils in particular cases, as in protecting hilly soils against washing and sandy soil against blowing.

TEMPERATURE

The presence of humus produced from decomposition of green manures tends to lessen extremes of temperature in the soil. Thus it will make it cooler in summer and warmer in winter; cooler in the daytime and warmer at night.

Extremely high temperatures in sandy soils in summer are prevented and the loss of valuable constituents which may result from such high temperatures is restricted. Very low temperatures in "cold" clay soils are likewise prevented and the transformation of mineral plant food into available form which might be restricted considerably is permitted to continue at a normal rate.

AERATION

Since green manures open up clay soils and make sandy soils more compact by adding organic matter, or humus, they have an important influence on the amount of air present in the soil. Humus acts beneficially on light, open soils in which too much air is apt to be present and in which destruc-

tive fermentative processes may occur with loss of valuable constituents. It restricts the entrance of air and reduces the destructive processes and consequently the losses. In heavy, tight, clay soils, on the other hand, fermentative processes are apt to be too slow. In these the organic matter from green manures opens up the soil, admits air, and permits the more rapid production of plant food. The subsoil is also opened up to a considerable extent and the unavailable plant food there is brought up and made available.

REACTION OR "SOURNESS"

The turning under of a crop of green manure adds a large amount of organic matter to the soil. In its decomposition, acids may be produced in considerable amounts and the soil become acid or "sour" in reaction. As is well known, sour soils are somewhat infertile, so when green manures are employed the reaction of the soil should be carefully tested. If it is acid, limestone should be applied in amounts depending on how "sour" the soil is and the crop to be grown.

THE CHEMICAL EFFECTS OF GREEN MANURES

Although the main effects produced in a soil by adding the organic matter contained in a green manure crop are physical, the chemical and bacteriological conditions are also influenced to a considerable extent, as well as the plant food production which is governed by these conditions.

THE CONSERVATION OF PLANT FOOD

Humus not only absorbs and retains moisture, but it also absorbs plant food which might otherwise be lost. It retains nitrogen in the form of ammonia, and it absorbs soluble potassium compounds which might be leached out of the soil and retains them for plant nourishment.

Nitrogen may be lost from the soil not only by passing into the air as ammonia, but also by the leaching of soluble nitrates into the drainage water and by the escape of nitrogen gas from nitrates into the air. There is very little plant food in the drainage water from soils under crops, while on fallow soils as much as 40 lbs. of nitrates may be lost annually. Hence the presence of green manure crops on the soil at times when it would otherwise be bare prevents the loss of nitrates as these are taken up by the plants and so stored in the soil for the succeeding crop. Furthermore, the period of most active nitrification in soils, that is, the time at which the greatest production of nitrates occurs, is during July and August and consequently if the soil is left bare following a small grain crop all the nitrates produced in the soil may be lost in the drainage water. It has been estimated that this loss of nitrogen from soils on which wheat is grown continuously amounts to 4 to 6 lbs. of nitrogen for each pound used by the crop.

The late summer and early fall is not only the period of greatest activity of the nitrifying bacteria, but also of many other species. Consequently, many other soluble plant food constituents are produced which might be lost by leaching if no crop were present to absorb and retain them.

THE CONCENTRATION OF PLANT FOOD

The green manure crops, especially the legumes, may act as collectors of plant food, building themselves up by drawing their nourishment from the lower soil layers. When such a crop is plowed under, all the food contained in it is stored near the surface for the benefit of succeeding crops. The roots of alfalfa, for instance, may extend from 12 to 30 feet downwards and much of its food is thereby brought up from the subsoil. This food is stored in the crop itself and in the large tap roots of the plants

near the surface. When the plants are turned under, this food is retained near the surface for the use of succeeding crops.

THE INCREASE IN AVAILABLE PLANT FOOD

When a green manure crop is turned under in a soil, moisture conditions being favorable, many species of bacteria begin to act on its mass of organic matter. They change the proteins, the complex, insoluble compounds which contain the nitrogen, into soluble proteins, then into amino acids, then into ammonia, and finally into nitrates, in which form the nitrogen is taken up by plants.

The non-nitrogenous matter in the green manure is also acted upon by various groups of bacteria which decompose the carbohydrate and cellulose materials more or less completely into carbon dioxide, organic acids, etc. This carbon dioxide and the organic acids act on the insoluble phosphorus and potassium compounds in the soil and change them into soluble, available forms. Thus the destruction of a green manure crop in the soil not only transforms the nitrogen in the crop into a form that plants can use but it also makes the plant food in the soil soluble.

THE INCREASE IN NITROGEN

When leguminous crops are used as green manures there may be an increase in the nitrogen content of the soils.

Legumes are independent of the nitrogen in the soil if their roots have so-called nodules, or swellings, which contain bacteria. These bacteria take the nitrogen from the atmosphere and supply it to the plants and thus there is no draft on the nitrogen in the soil. If the entire crop is turned under there is an addition of nitrogen to just the extent to which the nitrogen from the air is stored in the plants. For this increase of nitrogen in the soil to occur, the legumes must be inoculated; that is, if the proper bacteria are not already present in the soil, they must be put there. This is called "inoculation" and may be accomplished by the use of inoculated soil or by pure commercial cultures of the proper organisms. Further details concerning the inoculation of legumes may be obtained in Circular No. 8 of the Iowa Agricultural Experiment Station.

Green manures also bring about an increase in the nitrogen content of soils by encouraging the activities of the non-symbiotic, or free-living bacteria, supplying them with energy so they can fix nitrogen from the atmosphere in the soil.

THE BACTERIOLOGICAL EFFECTS OF GREEN MANURES

The bacteriological effects of green manuring depend so closely on the physical and chemical changes caused that it may be said that they are the direct result of those changes. The variations in moisture content, temperature, aeration, and reaction or "sourness" of soils caused by green manuring affect the bacteria very considerably.

Bacteria require water for their growth just as the higher plants do and they are similarly affected if there is too little or too much moisture. If the water content of a soil is very high, beneficial bacteria will be checked in their growth and the production of plant food, which is the main function of bacteria in the soil, will be reduced. So also if the soil becomes too dry, bacteria will be reduced in numbers and efficiency. Temperature has a certain effect on bacteria, some species growing best at moderately high temperatures and others preferring lower ones, and the activities of many beneficial species are reduced by extremes of temperature.

The amount of air present will determine to a large extent the kind of bacterial activity going on in the soil. If abundance of air is present then the aerobes, the bacteria needing air for their growth, will flourish and a large production of available plant food may occur. If the entrance of air

is restricted then the anaerobes, those bacteria growing without air, will prevail and the production of available food is restricted. The sourness of the soil also has an important influence on its bacterial activities. Bacteria generally prefer a soil which is not sour and if acids accumulate to any extent the numbers will grow considerably less and the production of available plant food will be correspondingly decreased.

Thus it is evident that as the use of green manures improves the physical condition of soils along these lines, beneficial bacterial activities are encouraged and likewise the production of plant food. In other words, improved physical conditions lead to greater bacterial action. Those bacteria which attack proteins and transforms them through the various stages already enumerated, into nitrates are encouraged. Those organisms also which attack purely non-nitrogenous compounds are more active; greater amounts of organic acids and carbon dioxide are formed and the transformation of insoluble phosphorus and potassium compounds into soluble form is increased.

We find therefore, that the chemical effects of the use of green manures which have already been discussed are the result of bacterial action. Available plant food in the soil is increased through the action of bacteria and the increase in nitrogen content by the use of legumes is the direct result of bacterial inoculation. A further increase in nitrogen in the soil may be brought about by the non-symbiotic nitrogen-fixing organisms which are encouraged to fix more nitrogen in the soil by the energy supplied in the organic matter of the green manure.

THE CROPS WHICH MAY BE USED FOR GREEN MANURES

There are two classes of crops which may be used as green manures, "nitrogen consumers" and "nitrogen gatherers." The "nitrogen consumers" prevent the loss of valuable constituents and improve the physical and absorptive power of the soil but add no nitrogen directly and the "nitrogen gatherers" have the same effects but in addition they put nitrogen into



Cowpeas on the Iowa Agricultural Experiment Station plots.

the soil. Among the first group we find the cereals, the grasses, buckwheat, turnips, rape, etc. Because of their time of growth and period of rapid development it is often desirable to grow them for green manures when the chief purpose is to save plant food and it is of only minor importance to add nitrogen to the soil. The second group includes all the legumes, such as the clovers, peas, beans, vetches, alfalfa, lupines, etc. The great advantage from the use of legumes for green manures is that they may be grown absolutely independent of the nitrogen in the soil. The nitrogen which a legume takes from the air is added to the soil when it is plowed under and that increases considerably the nitrogen content of the soil. As nitrogen is the essential plant food most apt to be lacking in soils, this adding it by plowing under legumes is quite an important consideration.

NITROGEN CONSUMING CROPS

Rye has many advantages as a green manure crop. It may be seeded late and will make a good growth during the late fall. It withstands cold winters well and makes an early spring growth and consequently may be plowed under for early crops. The cost of seeding rye is small and all farmers are familiar with the method of preparing for the crop and handling it. It absorbs the plant food which might be lost in the fall and it adds a large amount of humus to the soil, but it does not add nitrogen. The chief value attached to rye is its hardiness in withstanding cold winters and its early spring growth.

Wheat is less satisfactory than rye as a green manure for the reason that, although it is somewhat the same, it is not so hardy and does not make as early a spring growth. Furthermore, much more care must be taken in preparing the soil for wheat than for rye and the seed is more expensive. The value of wheat as a grain crop is too great to warrant its extensive use as a green manure crop.

Buckwheat makes a valuable green manure on poor lands. Its season of growth is during July and August and it is valuable therefore in keeping the soil covered during the hot weather of those months, preventing the loss of plant food which would otherwise occur. It also adds a considerable amount of humus to the soil.

Turnips are frequently used for green manures because of their rapid appropriation of plant food in cool weather. They make a large accumulation of organic matter in the late fall and if deep rooted varieties are employed, much plant food is brought up from the lower soil layers and stored in the crop for the benefit of succeeding crops.

Dwarf Essex Rape is occasionally employed to serve as a cover crop during the winter, as it may be grown in the late fall. It possesses no particular advantages over rye or the other nitrogen consuming crops.

NITROGEN GATHERING CROPS

Clovers are the most common and best known legumes and the good effects of their use as green manures is a matter of common knowledge.

Red Clover is perhaps the crop most generally used for this purpose. Its advantages are very largely due to the extensive root system which not only opens up the soil but also enables the plant to draw its food from the deeper soil layers and then store it in the surface soil. Furthermore, red clover is a very vigorous gatherer of nitrogen from the atmosphere. If the crop is well inoculated and the soil is poor in nitrogen subsequent crops may be benefited even when only the roots and stubble are left in the soil. When the whole crop is turned under for a green manure the addition of nitrogen to the soil may be very considerable.

Mammoth clover is very similar to red and possesses no particular advantages except that it grows better on wet land and produces a larger and

coarser plant and provides more green material to be turned under for a green manure.

Alsike clover is better adapted to cold, moist soils than the other clovers and it is much hardier, withstanding cold winters much better. It is a creeper and is preferably sown with some other crop, such as red or mammoth clover, to hold it up.



Sweet Clover

Crimson clover has been used with considerable success in the eastern states but it is affected by severe weather and is particularly sensitive to drought. It is essentially a cool weather plant, grows late in the fall and makes an early spring growth. Great care must be observed in preparing for this crop. Because of the difficulty in getting a good stand, it cannot be recommended for Iowa.

Sweet clover has been little used for green manuring but it has advantages which will certainly make it an important green manure crop in the future. It makes a rank growth and has a deep root system which enables it to bring up food from sources not reached by many other legumes. It grows best on soils rich in lime and it has been claimed that its roots decay much more rapidly than those of other legumes. Sweet clover grows readily in Iowa where the soils seem to be practically universally inoculated, leaving no doubt of the plant's ability to utilize the nitrogen of the atmosphere. It is easily grown and requires no more than the usual care in the preparation of the seed bed. As a whole, the use of sweet clover for green manuring purposes in Iowa is strongly to be advocated.

Alfalfa may be employed for green manuring but it is not very satisfactory. It is a perennial and reaches its best stage of growth in the second or third year. The expense of seeding is considerable and much difficulty is often experienced in securing a good stand.

Canada field peas are used considerably in Canada and in the northern states. They are well adapted to cool, moist weather, making early spring and late fall growth under such conditions.

They may be seeded when it is too late for other legumes and will make enough growth before frost to serve as a mulch during the winter, preventing losses from the soil.

Cowpeas are particularly adapted for warm climates but some varieties do well in cool climates also. They make a rapid and large growth during the hot summer months, when it is very desirable to have the soil covered. They possess considerable ability in the fixation of nitrogen and when well inoculated may add a large amount of this valuable constituent to the soil. They may be plowed under green in the fall or left on the surface as a mulch during the winter and plowed under in the spring.

Soybeans resemble cowpeas in many ways but they are more difficult to handle and they are more sensitive to cold. They should not be seeded until the soil is warm. While their yields are not so heavy as cowpeas, the plants contain more nitrogen in the dry matter.

Vetches, winter and spring varieties, are used for green manures with considerable success but the seed costs too much to make their use pay. They are superior to cowpeas or soybeans on light soils, and they may also be sown in the early spring or in the fall.

THE USE OF GREEN MANURES

Many important questions arise in the use of green manures. In the first place it is necessary to determine when green manuring should be practised and whether under the conditions a legume or a non-legume should be chosen. Then there must be careful preparation of the soil, and consideration must be given to the factors that influence the crop. Also, the farmer must take into account the effect of green manures on succeeding crops and the conditions governing the plowing under of the crop.

WHEN GREEN MANURING SHOULD BE PRACTISED

Green manuring should not be used without good reason any more than any other agricultural practice, for even the most commonly beneficial operation may sometimes injure the soil. Thus while general principles and



Cowpeas in Corn

directions governing the use of green manures may be given, local soil, climatic and other conditions are of so much importance that definite advice cannot be given without knowledge of these particular conditions.

In grain farming, where the produce is sold from the farm, there is a rapid decrease in fertility. The soils become poor not only in the essential plant food constituents but also in organic matter, while their physical condition becomes unsatisfactory for crop growth. An ample supply of humus is one of the essential requisites for the maintenance of soil fertility and in grain farming the only logical way to insure this supply is by the use of green manures. When a leguminous green manure crop is introduced as an addition to the regular rotation, the humus content of the soil is maintained and besides much nitrogen may be added.

Just where to introduce the green manure in the rotation will depend entirely on the rotation. If that contains corn, then a green manure crop may be sown in the corn, allowed to remain on the ground during the winter and turned under in the spring. Thus in the common Iowa rotation, which consists of corn, corn, oats, and clover, green manures may be used in connection with both corn crops if it is deemed necessary. It should be used in at least one crop. The fact that the soil is kept covered during the winters following the corn crops is an important point in favor of the use of clover crops in such case.

In live stock farming, much of the fertility removed from the soil by the crops may be returned by the proper storing and use of the manure produced on the farm, assuming of course that all the produce of the farm is fed on the place. Even under the best conditions, however, all the fer-

tility removed by the crops cannot be returned in the manure and hence green manuring has a place also in live stock farming. Where green manures are used twice on a grain farm there would probably be no need to use them more than once on a stock farm. Here, again, local conditions will determine to a large extent the need and frequency of the need of organic matter in the soil.

THE CROPS TO BE EMPLOYED

The relative advantages of legumes and non-legumes have been mentioned, the latter having the same effects as the former to a large extent except that non-legumes do not put nitrogen into the soil.

Sometimes a non-legume may accomplish just as satisfactory results as a legume at a less expense and in such cases there is no question as to which should be employed. Thus rye may sometimes be used as a cover crop on soils following the corn crop with as much beneficial effect as a clover. If the soil is rich enough in nitrogen and it is desired only to add organic matter, improve the physical condition of the soil, and prevent the loss of valuable constituents, then a non-legume may be cheaper than a legume and just as good. Again, the local conditions, including the apparent needs of the soil, must aid in the selection of a crop for a green manure.

The value of sweet clover as a leguminous green manure crop for Iowa soils has already been pointed out and tests of its use as a means of maintaining the fertility of the soils of the state cannot be too strongly urged.

THE CONDITIONS GOVERNING THE CHOICE OF A CROP

Certain conditions should be observed in the choice of a crop. Among these are the cost of seed, the suitability of the crop to the particular climate, and the character and need of the soil. The ease with which the crop may be plowed under is another point of importance and the ability of the plant to choke out weeds is also of interest if the crop is to be used for that purpose on soils permitted to remain bare during the late summer and fall.

When legumes are grown, the ability of the plant to secure nitrogen from the atmosphere must in addition to the above then be considered. Some legumes seem to have more power of utilizing atmospheric nitrogen than others. How deep the plant's roots go is another point of interest, for the deeper the root system the greater the feeding district of the plant and the more plant food will be brought up from the deeper soil layers and stored near the surface. Furthermore, the deeper the roots go into the subsoil, the more it is opened up, and the greater is the admission of air. Increased aeration is followed by increased bacterial activities and greater plant food production.

Finally, in the choice of a green manure crop, its forage value and the quality and quantity of hay or pasture it may produce must be considered. Thus in some cases it may be more profitable to use the crop for forage or hay or to pasture it than to turn it under for a green manure. It must be remembered that the roots and stubble of legumes make an important addition to the soil, even although no decided gain in nitrogen is accomplished. The nitrogen content of the soil need not be depleted to any extent by the growth of legumes if proper inoculation is performed. If the humus content is not seriously reduced and it is not necessary to make large additions of organic matter or nitrogen to the soil to bring it to a fertile state, the use of the crop for feeding purposes may be more profitable.

THE PREPARATION FOR A GREEN MANURE CROP

The soil must be put in as good a state for the growth of a green manure crop as for any other crop. The seed bed must be just as carefully prepared as if the crop were to be harvested. The soil must have the necessary plant food, except that in the case of legumes no nitrogen is necessary, pro-

vided there is proper inoculation. Thus enough phosphorus and potassium must be present; if not, the crop will be a failure and the expense and trouble of planting will be wasted. The reaction or sourness of the soil must be carefully determined, particularly in the case of legumes, some of which are very sensitive to slightly acid conditions. In such cases applications of ground limestone should be made before seeding to the legume. Where legumes are used it is essential also that there be inoculation. The proper bacteria must be present so that the plants may take their nitrogen from the air and be independent of the nitrogen supply of the soil. The soil may be inoculated either by the use of soil from a field where the legume has previously been successfully grown or by the use of pure, commercial cultures. The former method is still recommended because the latter is not yet certain. Inoculation by using from 300 to 500 lbs. per acre of soil from a well inoculated field of the same legume have never been known to fail.

THE EFFECT OF GREEN MANURES ON SUCCEEDING CROPS

Many experiments have been carried out showing the effects of green manures, notably legumes, on succeeding crops. While of course these effects vary with the crop employed, as well as with the local conditions, they have in most cases been very striking. For instance, red clover has been shown to increase the succeeding crop of corn to the extent of 20 bushels per acre, and the following crop of oats to the amount of 10 bushels per acre. Potatoes have shown a 30 bushel increase when grown following red clover as a green manure. Cowpeas have given similar increases under certain conditions and other legumes have caused varying increases in subsequent crops. Occasionally some crop may be unfavorably affected by the use of green manures. The large amount of organic matter sometimes leads



! Cowpeas in Oat Stubble



Cowpeas in Standing Corn

to the extensive production of nitrates which may cause the increased development of leaves, and delay the ripening of some fruits, or cause the lodging of some grains. With these few rare exceptions, however, green manures have been shown to increase the yields of subsequent crops to a profitable extent.

THE PLOWING UNDER OF GREEN MANURES

The time of plowing under green manure crops will be determined by various factors, among which are the season of growth of the plant, the condition and character of the soil, and the weather and other seasonal conditions. The crop should be plowed under in a green condition when it is full of moisture as then the decomposition processes are favored and its destruction takes place more rapidly.

If the plants are matured, they have become woody in structure and decompose very slowly and may cause drying out of the soil by the increased evaporation which they cause. If a heavy green manure crop is plowed un-

der when the soil is dry, and in warm, dry weather, the soil may be injured by the reduction of the moisture content and succeeding crops may suffer for lack of water. On the other hand, if green manures are turned under in the late fall, the decomposition processes are very slow and acid conditions may be developed in the soil. In short, the ideal conditions for the decomposition of green manures are abundance of moisture and a moderately high temperature. When fall sown crops are to follow green manures the green manure should be turned under at least four weeks prior to the planting of the crop and the soil thoroughly harrowed and compacted to insure proper decomposition of the green matter.

CONCLUSION

In conclusion, the importance of green manuring in all systems of permanent agriculture cannot be too strongly emphasized. In no other way can the humus content, and therefore the fertility, of a soil be as cheaply maintained.

The manure produced on the live stock farm, although it does constitute a means of returning to the soils of such farms a portion of the fertility removed by crops, is insufficient to keep the soil fertile. In grain farming, when the produce is sold, there is absolute necessity of some means of returning valuable constituents, for on these farms the manures produced are of little significance, representing as they do such a small portion of the crops grown. It makes no difference therefore, whether grain farming or live stock farming is practised, no rotation of crops which does not permit of the introduction of some "cover" or "catch" crop should be considered satisfactory.

The wearing out of Iowa soils is no idle prophecy, it is a reality, which is now close upon us. Already some Iowa soils are beginning to decline in fertility as evidenced by decreasing crop yields and the reason is that proper methods of farming are not practised.

Every farmer should consider well the essential factors influencing soil fertility, which have been enumerated in this circular. He should use all precautions that his soils do not become infertile because of improper rotations, poor drainage, lack of care in the preparation of the seed bed and the cultivation of the crop, insufficient plant food, the development of acid conditions, or deficiency in humus content. Observing all these precautions there is no need of Iowa soils wearing out; and neglecting them there is no doubt but that such a wearing out will occur.

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Agronomy Section, Farm Crops

Smut in Small Grains

With Treatments for its Eradication

H. D. HUGHES

P. C. TAFF

Smut is one of the most common and widespread diseases of cereals and causes an annual loss on Iowa farms of many thousands and often millions of dollars. Smut not only cuts down yields, but it often seriously impairs the quality of grain and lowers the price per bushel. It is fortunate that smut is unlike many of the other fungus and bacterial diseases of farm crops, in that it can be destroyed easily and at very little expense.

To find out how much grain is lost in Iowa each year, the farm crops section of the Agricultural Extension department sent out about 12,000 circular letters to practical farmers asking for careful counts of per cent of smut in their fields. These were sent to farmers who attended state and local short courses and to two-year students at Iowa State College in 1911-12. Each was asked to make at least one count in a neighbor's field as well as his own. The large number of counts assures accuracy and gives just about the actual conditions existing in Iowa.

A total of 3,668 counts were returned complete. Of these 3,356 were made in fields where the seed was treated for smut and the remaining 312 in fields that were treated. The following are the results:

In oats not treated.....	7.3 per cent smut
In oats treated.....	1.9 per cent smut
Acres represented in untreated fields.....	11,037 A.
Acres represented in treated fields.....	1,218 A.

Taking these figures as a basis, it will be seen that less than 10 per cent of the seed oats used in Iowa last year were treated for smut. Considering the total loss represented, and the ease and slight expense required for its prevention, Iowa should be more interested in driving smut out of its oat fields.

While the average per cent of smut in all fields where the seed had not been treated was 7.3 per cent, the loss in some fields was over 45 per cent. Every man who fails to treat his seed oats risks such a heavy loss.

In the average treated fields there was 1.9 per cent of smut. Since repeated tests indicate that the smut can be entirely destroyed when the seed is *properly treated*, this loss indicates that much of the work was either too carelessly done or that the formalin used in some cases was not of the proper strength. Taking all fields, however, the treatment resulted in a reduction of 5.4 per cent in the number of smutted heads.

Basing calculations on the average given for 1912, we find that had all the seed oats used been treated with even the same degree of effectiveness, it would have meant a saving on our Iowa farms of 2.2 bushels per acre, or a total of 10,841,600 bushels.

WHAT IS SMUT?

Smut is a fungous plant. It cannot gather its own plant food from the soil and water and make it into plant tissue with the aid of sunlight. It must get its food supply from other plants and, therefore, it is called a parasite. The smutted heads of oats, barley or wheat, as we commonly see them, are caused by the growth of the seed or spores of the smut plant. The smut seed germinates in the ground along with the grain seed and then sends its shoots up within the tissue of the grain plant, feeding upon the juices of the latter. As the grain plant grows and its flowers develop, the smut plant steals the juices intended for the developing grains and uses them to make its own seed or spores. These spores are the black masses which appear in the place of the grain seed and number millions. As the smut ripens these spores are blown about by the winds, infecting other plants and thus continuing in the crop year after year.

THE KINDS OF SMUT

Several different kinds of smut attack our small grains, and the treatments which are effective against some of these have no injurious effect upon others.

The smut most commonly found in Iowa is the "loose smut" of oats. The smut which is second in importance is the "covered smut" in wheat (also called "stinking smut" or "bunt"). Both of these can be easily eradicated. The loose smut of barley and the loose smut of wheat are met with less rarely, particularly the latter, though both are of considerable importance. The covered smut of barley is met with still less frequently.

The smut of one grain does not affect any other kind of grain. For instance, oat smut is an entirely different smut from the one attacking wheat or barley.

METHOD OF INFECTION

The method of infection varies greatly with the different smuts.

The spores of the loose smut in oats and stinking or covered smut in wheat ripen at about the same time as the grain and become attached to the seed grain just as dust particles might do. This may happen in the field or it may be distributed in threshing, as is probably the most usual method with the covered smut. When the infected seed grain is planted in the spring and germinates, the smut spore also germinates and the parasite plant develops within the tissues of the wheat or oat plant.

The loose smuts of barley and wheat infect the grain crop in an entirely different manner. The spores develop somewhat in advance of the grain crop, the spores being blown about just at the time when the flowers of the wheat or barley are open for fertilization. Many of the smut spores lodge within the glumes or hulls of the small grain. They come in contact with the ovary, sprout and enter the plant cells which are ultimately to be a part of a seed. Here they lie dormant until the seed is planted, when both seeds germinate, the smut plant growing up within the tissues of the wheat or barley plant. As the grain crop

is about to produce seed the smut plant announces itself by developing its own seed or spores in place of the grain.

METHODS OF TREATING SEED TO PREVENT SMUT

The spores of the small grain smuts which are blown about by the wind and fall upon the ground, are ineffective in producing smut in the following year's crop. To prove effective the smut spores must come in direct contact with the grain seed. This fact makes it possible to prevent smut in the following crop by treating the seed grain.

The method of treatment varies with the manner in which the smut infects the crop. In case of the loose smuts of barley and wheat when the smut is lodged in the tissues within the wheat or barley kernel, it is apparent that any treatment which affected only the outside of the kernel would be entirely ineffective. The treatment of seed to prevent this smut becomes therefore rather complicated, owing to the danger of injuring the vitality of the seed grain in an attempt to reach and kill the smut spore. Fortunately, however, these smuts are not nearly so prevalent in the state as the loose smut of oats and the covered smut of wheat in which the infection is on the outside of the grain where it can easily be reached.

Several very effective methods are known for treating the various smuts. Only one of the most practical and simplest methods will be mentioned for each type of smut.

TREATMENT OF SMUT OF OATS, STINKING OR COVERED SMUT OF WHEAT, AND COVERED SMUT OF BARLEY

The formalin treatment for these smuts is without doubt the easiest applied, one of the cheapest, and most effective. The formalin can be bought at any drug store at a cost of 50 cents to \$1.00 per pound, or pint. It should be procured in sealed bottles if possible to insure its strength. Many failures in treating can be traced to weak formalin. This product is a solution of formaldehyde gas in water and will lose its strength rapidly if left uncorked or kept long in unsealed bottles.

One pint of formalin is added to 40 gallons of water, mixed thoroughly and applied to the grain at once. This amount of solution will treat about 40 bushels of seed.

One good method of applying the solution is to spread the grain on a floor, or in the bottom of a wagon-bed. Use a common garden sprinkler to put on the solution and sprinkle until wet, mix the grain with a shovel and sprinkle again. Every grain must be thoroughly wet with some of the mixture or the smut will not be killed. After sprinkling, put the grain in a pile and cover with blankets or sacks for 10 to 12 hours or over night. This will kill some smut which otherwise would not be touched. Spread the grain out and sow as soon as sufficiently dry.

Another method often used in treating is to put the grain in coarse sacks and immerse in a barrel of the solution, where they should remain for 10 minutes, at the end of which time they should be raised above the solution and allowed to drain for a short time when they may be spread out and dried as when sprinkled.

The idea to keep in mind is that each grain must be thoroughly wet with the solution or the smut spores will not be killed.

TREATMENT FOR LOOSE SMUT OF WHEAT AND BARLEY

The treatment for these smuts must necessarily be different from the others just mentioned. As before stated the growth is entirely different. The modified hot-water treatment is recommended for these smuts.

The seed is soaked in cold water for four or five hours. It is then removed, drained and given the regular hot-water treatment. That is done by first placing in water kept at a temperature of about 120 degrees F., then for wheat it is placed in water at 129 degrees F., for 10 minutes, and for barley 126 degrees F., for 13 minutes. If the temperature should be lower than that recommended the grain should be soaked slightly longer.

It is of the utmost importance that the temperature should be kept at very near the temperature given. If it becomes too hot the vitality of the grain may be seriously injured and if cooler the smut may not be killed.

Seed grain treated by the hot water method should be tested for vitality before seeding in order that the rate of seeding may be increased if necessary.

IOWA AGRICULTURAL EXPERIMENT STATION

Animal Husbandry Section

Soiling Crops to Supplement Iowa Pastures

By H. H. Kildee

The pastures upon most Iowa farms do not furnish enough feed for the cattle during the hot, dry months of summer. The problem of supplying the necessary feed most economically is important and may be solved by one or a combination of the following methods:

1. Better care and management of pastures.
2. Use of summer silo.
3. Use of soiling crops.

Better care and management of pastures is absolutely necessary to secure the best results from our farms. In every neighborhood practical demonstrations may be found that a little care given to a pasture will greatly increase its production of feed for live stock. But this in itself is not enough for dairy farmers or for many beef cattle growers. To secure the greatest possible returns from their farms, they find it to their advantage to keep more cattle than they can properly pasture without the aid of silage or soiling crops. The use of silage or soiling crops upon dairy farms results in a saving of land, fencing, food and manure and in greater and more profitable production of milk.

SILAGE OR SOILING CROPS.

Whether corn silage or soiling crops will be more economical and efficient in supplementing the pasture will depend somewhat on specific conditions. The experimental work which has been conducted along this line has not furnished very conclusive evidence in favor of either.

Evidently a silo small in diameter filled for summer use is the most satisfactory and economical solution of the problem on the average Iowa farm. Most of the soiling crops require more labor in getting them to the animals than the average farmer, who practices mixed farming, wishes to spare from the field work in the busy season of the year.

However, the man who has a large herd of dairy cattle and wishes to secure the best possible returns from his acreage will find it to his advantage to grow some soiling crops. There is nothing better than fresh, palatable, nutritious green feed to stimulate milk production. Then, too, by having in each mixture a leguminous plant, soiling crops can be grown that are superior to corn silage in balance of nutrients. Another class of farmers who would profit by the use of soiling crops

is the renters who can not persuade their landlords that silos are necessary fixtures upon farms. To these classes must be added the men who have not put up silos yet and who wish to grow crops to feed in addition to their pastures during the coming summer. All of them may adopt the common practice of cutting green oats, sweet corn and field corn to tide the cattle through the short pasture period, but that is not as satisfactory or profitable as to grow crops that are adapted for this purpose and can be cut at the proper stage of maturity.

In answer to the many questions which are being received at the Iowa Agricultural Experiment Station, this circular on soiling crops has been prepared.

SYSTEM EMPLOYED ON COLLEGE DAIRY FARM.

During the past three years soiling crops have been successfully grown and used upon the Iowa State College dairy farm at Ames. Such varieties have been grown as would furnish a succession of green feed to supplement the limited acreage of blue grass pasture. Under this system the cows have been turned into the pasture nights and forenoons and then put in the barn about 2:30 p. m. and given a liberal allowance of the freshly cut green feed. Under ordinary dairy farm conditions the above, or partial, soiling system is more satisfactory than to keep the cows confined all the time and haul all the green feed to them as is done on some of the larger dairy farms. It is also much more satisfactory than to feed the cows the green feed on the ground in the pasture as is sometimes done with much soiled and wasted feed as a result.

RESULTS OBTAINED.

Increased production of milk from decreased acreage has been the result secured from this system of soiling crops. By bringing the cows into the barn at the time of day when the heat and flies are especially troublesome and spraying them to remove flies, it is made possible for them to eat their feed in comfort. Thus they are enabled to keep up a normal flow of milk when they would ordinarily decline seriously. We have also found that because these palatable green crops are used, less grain needs to be fed our heaviest producers and that ordinary producers may be kept up in production and condition without grain.

In 1911 thirty-seven cows were kept on 19½ acres of pasture and in addition were supplied with the soiling crops from 8 acres. Counting the land devoted to both pasture and soiling crops each cow was kept the entire season on .74 of an acre. The value of the soiling crops may be fully realized when it is remembered that the summer of 1911 was one of scanty rainfall and many farmers in the vicinity of Ames were allowing 2½ or 3 acres of pasture for each cow. In 1912, 45 cows were kept on the 19½ acre pasture and in addition were allowed a trifle over 6 acres of soiling crops—or each cow was kept on about .6 of an acre. In addition to this, in 1912 the cows grazed on a 15 acre meadow for a few weeks, beginning about the middle of August. It was found in 1912 that the entire cost of pasture and soiling crops for each cow, counting rent of land, labor, seed, etc., was only \$6.62 for the entire pasture season.

LABOR.

The objection usually raised to growing soiling crops is the amount of labor necessary to cut and haul the feed to the cows each day. We have found that this takes two men about one and one-half hours each day. In 1912, with the larger number of cows, it was found that a team and mower could be used to good advantage in cutting the daily

allowance of feed. Considering the value of soiling crops in increasing production and decreasing cost of production of dairy products, it will be found that excellent returns are secured for time spent.

CROPS GROWN.

OATS AND CANADA FIELD PEAS: We have found it most satisfactory to make two sowings of this standard crop. We put in the first plot as soon as the ground is ready for oat seeding in the spring and the second about two or three weeks later. We use an early maturing variety of oats in sowing first plot and a late maturing variety in the second seeding. This first sown plot is usually ready for cutting about June 15 and the second about July 5. When sown at the rate of $1\frac{1}{2}$ bushels of oats and $1\frac{1}{2}$ bushels of Canada field peas per acre, excellent results have been obtained. Some, however, advocate using $\frac{1}{2}$ bushel less of the Canada field peas. The grain drill is the most satisfactory to use in putting the crop in. It is best to sow the peas first and deeper than the oats. However, excellent results were secured where the two were sown together.

In 1912 the yield from the first sown plot was $5\frac{1}{2}$ tons of green feed per acre and from the second sown plot 4.38 tons per acre. In 1911, due to lack of rainfall, the yield was somewhat less, ranging from 4 to $4\frac{1}{2}$ tons per acre.

The question of how large a plot should be sown for a certain number of cows is oftentimes asked. However, this is a question that should not cause worry as that part of the crop not utilized as greenfeed will make excellent hay. In 1912 for the 45 cows on $19\frac{1}{2}$ acres of pasture we had 1.71 acres in first plot and .8838 acres in second.

FODDER CANE: This is an excellent and widely grown forage plant. In our work we have found it to yield very heavily and to be very palatable and nutritious. Cattle eat it readily and waste but little of it if fed in a manger, except when the cane is advanced in maturity when the animals will leave some of the larger stalks if heavily fed. If sown early in May the cane will be ready to start cutting about July 10. It should be sown in limited areas so that part of it will not become mature before it is fed. Upon rich ground it is best to drill the seed in with a grain drill using all the drills as a dense growth results in finer stalks with less fibre. Sowing in this way requires about 70 pounds of seed per acre. In 1912 the yield of green cane was 23.28 tons per acre.

FODDER CANE AND COW PEAS: This combination has proved to be one of the best we have tried. As a feed it has given better results than either cane or cow peas alone. This is due no doubt to the fact that the combined crop is more palatable than cow peas alone and more nearly balanced in nutrients than cane alone due to the protein in the cow peas. This crop can not be safely put in until the ground has become warm. We drill it in soon after corn planting. Our experience would indicate that from the time the ground is warm enough for the cow peas until the first frost comes in the fall that no better crop can be grown for soiling purposes. It is best to drill the cow peas and cane separately; the rate of seeding used has been one bushel of cow peas (Whip-poor-will or New Era varieties) and 30 pounds of cane seed per acre. The yield of green feed per acre in 1911 was about 10 tons while in 1912 it ranged from 7.1 tons upon rather poor soil to 14.62 tons upon good soil.

MILLET: This is not as good a crop for soiling purposes as the ones just mentioned but as it is not materially injured by a light frost it may be used later in the fall than the cane and cow peas. The plot of ground used for the first sowing of oats and Canada field peas may be plowed after the removal of the crop early in July and sowed to millet,

By sowing the millet about July 8 in 1911 a fairly good yield of millet was secured and due to the delayed heavy frost, it was used until October 26. In 1912 however, the heavy killing frost came so early that practically none of the millet could be used for soiling, but was cut for hay. Millet has been sown at the rate of 3 pecks per acre and has yielded from 2 to 3½ tons per acre.

ALFALFA: Green alfalfa may be utilized for soiling three times each season and it is needless to say that it is one of the best crops. It is first ready early in June just before the oats and Canada field peas and then again just before the cane and cow peas are ready for use. The third cutting comes on just when the cows appreciate a change from the cane and cow peas.

OTHER CROPS GROWN: Rye has been tried but found to be inferior as a soiling crop. While it is of value as an early pasture it is deficient as a soiling crop because it comes on when it is not usually necessary to supplement the pasture and it is in proper stage of maturity for soiling but a very short time and it lacks palatability.

Cow peas and Soy beans have not been found to be especially valuable as soiling crops when grown alone, although when grown with cane the cow peas are excellent. While they make excellent hay, as green crops they seemed to lack palatability.

Because upon most farms sufficient pasture is allowed to give the animals the necessary feed until the middle of June at least, the following outline of a succession of soiling crops will doubtless prove of value.

SUCCESSION OF SOILING CROPS USED ON THE IOWA STATE COLLEGE DAIRY FARM

Approximate time of Cutting	Crops	Approximate time of Sowing	Rate of seeding per acre	Average yield of green feed per acre
June 10 to June 15	Alfalfa	Spring or Aug.	20 lbs.	*8 tons
June 15 to July 5	Oats and Can- ada Field Peas	April 5	1½ bu. oats 1½ bu. peas	5 tons
July 1 to July 10	Oats and Can- ada Field Peas	April 20	1½ bu. oats 1½ bu. peas	5 tons
July 10 to July 15	Alfalfa	Spring or Aug.	20 lbs.	*4 tons
July 10 to July 20	Amber Fodder Cane	May 5	70 lbs.	20 tons
July 15 to August 15	Fodder Cane and Cow Peas	May 15	30 lbs. cane 1 bu. cow peas	12 tons
August 15 to September 20	Fodder Cane and Cow Peas	June 10	30 lbs. cane 1 bu. cow peas	12 tons
September 20 to heavy frost	Millet	July 10	3 pecks	3 tons

*The first cutting of alfalfa yielded 2.96, the second cutting 1.46 and the third 2.61 tons of cured hay per acre in 1912-

IOWA AGRICULTURAL EXPERIMENT STATION

Horticultural Section

POTATOES

Laurenz Greene

T. J. Maney

This circular will answer the many inquiries received by the Iowa Agricultural Experiment Station relative to different phases of potato culture. More complete information on the investigational work now under way at the Station at Ames will be published later in a regular bulletin.

VARIETIES.

Early Ohio and Rural New Yorker are the leading early and main crop potatoes, respectively, now grown in Iowa. In addition to these two, other varieties have given as good or better results at Ames and should have a thorough trial in other sections of the state. They are:

Early.

BOVEE: A good-sized variety, oblong, thick; yellowish white with pink markings.

EARLY SIX WEEKS: Round and oval, medium to small in size, the skin is smooth with netted spots at one end and is brownish pink in color.

EARLY ROSE: This is a pink potato with smooth skin. It is medium in size and cylindrical in form.

BEAUTY OF HEBRON: A large, oval, white variety with a smooth skin.

EARLY ROSER: This is a medium sized, elongated kidney shaped variety the color of which is bluish white tinged with brown. The skin is slightly netted to coarsely roughened.

Late or Main Crop.

PROSPERITY: The skin is smooth or slightly russeted white. Large in size and elongated, broad and flat.

PEERLESS: A large white variety, with finely netted skin. It is oblong, and rather flat.

IONIA SEEDLING: Roundish, often tapering and flattened. It is medium to large and yellowish white.

VERMONT GOLD COIN: Another yellowish white variety but with a russeted skin. It is medium to large in size and roundish oblong in shape.

NORCROSS: A white variety, medium to large in size, and roundish or nearly blocky in form.

CARMEN No. 3: Large, white, oblong, flattened.

These varieties will not be adapted to all soils of the state but they are worthy of a trial to determine whether they are superior to the older sorts.

TIME OF PLANTING.

No absolute rule can be given as to the best time to plant potatoes. The best time will vary with the seasons. Early varieties may be planted as early as the season will allow.

The later or main crop varieties should not be planted too early. They are apt to mature early in the fall and either rot before digging time or in wet weather start a second growth. During the past three years planting in the month of May has given the best results at Ames. Results will vary with the soil and with the seasons, but doubtless the main crop may be planted between April 25 and May 25 and the highest yields obtained thereby. Good results will follow planting through a much longer period. A ten year experiment is under way at Ames to throw light on this problem.

TREATING THE SEED FOR SCAB.

Potato tubers should not, under ordinary conditions, be planted without first treating them to prevent scab. The best method is to soak the whole tubers for two hours in one of the following solutions:

Corrosive Sublimate Treatment.

Corrosive sublimate-----2 ounces
Water-----15 gallons

(Corrosive Sublimate can be purchased at drug stores in small tablets.)

This solution is a strong poison and care should be exercised in its use. Only wooden or earthenware vessels should be used.

Formalin Treatment.

Formalin (Formaldehyde 40 per cent)-----1 pint
Water-----30 gallons

(Commercial Formalin is on sale at ordinary drug stores.)

The latter treatment is advised as the formalin is nonpoisonous and not so dangerous to handle. With either solution the tubers should not be soaked longer than two hours as distinct injury will result to the eyes or sprouts if they remain in the solution too long. Soak the tubers before cutting them or there will result a loss of many sprouts and a decrease in stand and yield. After treatment spread the tubers out to dry. Then they may be cut and planted, or stored. Clean bins or bags that have not held scabby tubers must be used, otherwise treated potatoes may become infected again. After the seed is cut it should not stand too long before being planted, although a few days delay will not cause a loss if heating is prevented.

Formaldehyde gas has been used and extensively recommended for seed treatment for scab. Results from its use at Ames have shown that while it will control the scab there is a great loss of vitality in the seed which results in a loss of stand and yield.

SPRAYING.

Spraying is one of the most profitable parts of potato culture. It almost invariably brings a large net profit as compared with its cost. The early blight and the late blight are the two diseases that must be combatted. The Colorado potato beetle and the flea beetle are the two important insects in Iowa. Other insects and diseases will occur, but the treatment for those named will control most of the other common ones. Spraying with bordeaux mixture for the early blight should begin when the plants are from six to eight inches high and should be continued at intervals of from ten days to two weeks thereafter. These same applications will control the late blight also. By adding three pounds of lead arsenate to fifty gallons of the bordeaux mixture at each spraying the insects can be controlled. One-half pound of paris green may be used in place of the lead arsenate.

BORDEAUX MIXTURE.

To prepare this mixture dissolve five pounds of copper sulphate or blue stone, in a small amount of water, dilute this to twenty-five gallons. Slake five pounds of lime and after it is well slaked dilute to twenty-five gallons and add slowly to the copper sulphate solution. These should not be mixed in the concentrated solution but in the dilute solutions as indicated. This will make fifty gallons of mixture or about enough to spray one acre once. In applying this mixture with traction sprayers it is important that every part of the vine be covered and it is better to use from two to three nozzles on each row rather than to trust to one to do good work.

CULTIVATION.

Thorough cultivation of potatoes, as of other crops, will pay good returns on the time and labor invested. Harrow after planting and again just as the young plants are coming through. The small weeds are easily killed at this time. Cultivate frequently thereafter, making from four to seven cultivations for the season. Dry seasons will require more thorough cultivation though cultivation is important in wet seasons. All weeds should be kept out with the hoe when necessary.

IOWA AGRICULTURAL EXPERIMENT STATION

Veterinary Section

Some Common Internal Parasites (Worms) of Hogs and Their Treatment

BY

DR. C. H. STANGE

Next to hog cholera, probably no subject is of greater importance to swine raisers than that of worms in hogs. Intestinal worms in hogs is a common condition. An understanding of the mode of infestation and the methods of prevention and treating these common parasites will largely prevent losses from worms in swine herds.

In this bulletin the more common types of worms affecting hogs are described and suitable remedies are suggested. The reader is urged to make certain, if possible, the nature of the affection before applying the treatment. Complicated or difficult diagnosis should be referred to competent veterinarians in order to secure the best results. The descriptive material on the following pages is too brief and incomplete to be of value except in ordinary affections, such as are too often overlooked, or subjected to home treatment, or perhaps escape treatment entirely.

Most of the worms for which the hog is host are more numerous some years than others, this being due to the fact that conditions are more favorable some seasons for the complete development (life history) of the parasite in its various stages. It may seem strange that the common intestinal worms of the hog pass a part of their life history outside of the body of the hog. Such, nevertheless, is the case. Whether or not these parasites perish during this time depends largely upon conditions, i. e., moisture, warmth, etc.

WORMS INFESTING THE INTESTINES

The most important worms of the hog are the large round worms infesting the intestine, and the small thread-like ones found in the lungs. The former are by far the most frequent and are most readily and effectively treated.

The COMMON ROUND OR LUMBRICOID WORM (*Ascaris Suilla*) prefers to live in the small intestine but has frequently been found in the stomach, bile ducts and in the gall bladder. It is a common parasite in young, unthrifty pigs and may be found in sufficiently large numbers to fill the intestine for several feet. It is a round worm, tapering at both ends, white or yellowish white in color. The female worm averages nine to ten inches in length, while the male is usually about three inches shorter. The eggs laid by the female pass out with the intestinal contents, and soon hatch if the ground is moist and warm. If not, they remain in the egg stage for sometime. Hogs feeding on dirty floors or from the ground or drinking from dirty troughs or ponds, take in the newly hatched worm or eggs about to hatch, and from this time on growth and development in the hog's intestine



Common Round Worm
(*Ascaris Suilla*)

into a fully matured worm are simply a matter of time.

THORN HEADED WORM (*Echinorynchus Gigas*). This worm is somewhat larger than the common round worm, the female often reaching eleven inches in length. The male is much smaller and will average about three inches in length. The color of both male and female is a milky white, the body is somewhat wrinkled transversely and tapers to a blunt point at the posterior extremity. The anterior extremity (head) carries a hook which can be drawn back and which is covered by many small hooklets which curve backward. The worm attaches itself to the wall (inside) of the intestine by means of this hook.

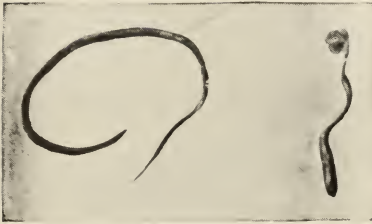
The eggs pass out with the manure as with the common round worm. They are then taken up by the white grubs (larval form of May beetle) which are found about manure piles. It is possible that some forms of the snail may also take up these eggs, and unless they are taken up by the common grub or the snail their further development stops. Hogs become infested by eating the grubs and snails. Hogs pastured on clover seem to show the greatest infestation.



Thorn Headed Worm
(*Echinorynchus Gigas*)

The PIN WORM (*Desophagastoma Dentatum*) is a small white or brownish white worm, pointed at both ends and often found in large numbers in the first portion of the large intestines. The male is one-half inch long, the female averaging a little longer. They rarely create much disturbance, but probably assist in aggravating the symptoms when other parasites are present. The animal becomes infested through the same source as with the common round worm.

The WHIP WORM (*Trichocephalus Crenatus*) is generally found in same portion of the intestine as the pin worm. It is about one and one-half inches in length.



Lung Worm
(*Strongylus*
Paradoxus)

Whip Worm
(*Trichocephalus*
Crenatus)

The anterior two-thirds of the body is very thin (whip lash) while the posterior one-third expands suddenly at its juncture with the anterior portion and is cylindrical and quite thick (whip stock) as compared with the anterior portion, whence the name, whip worms. The eggs pass out, develop and are taken in as with the common round worm. The effect on the hog is about the same as with the pin worms.

SYMPTOMS OF WORMS IN HOGS.

The severity of the symptoms depends quite largely on the number of worms present. The presence of more kinds of worms usually aggravates the symptoms. A few worms may be present without producing appreciable symptoms.

Among the most common symptoms are those seen in chronic indigestion, i. e., irregular appetite, alternate diarrhoea and constipation, loss of condition, sometimes vomiting, rough coat and other symptoms of unthriftiness. When thorn headed worms are present there is considerable irritation of the lining of the intestines and there are in addition to the above symptoms, restlessness, weakness, and in young pigs, convulsions. The most certain method of determining the presence of intestinal worms is to find worms or their eggs in the manure.

PREVENTION AND TREATMENT.

The prevention is very important and consists of methods having for their object the destruction of the eggs outside of the body so as to prevent further infestation. Inasmuch as moisture is an important element in assisting the eggs to hatch all pastures should be well drained, and wallow holes should not be allowed to form. The water supply should come from a deep well, and the feeding troughs and floors should be kept as clean as possible. When possible, a frequent change of pasture is recommended. When thorn headed worms are present, hogs should not be allowed to root about old straw stacks and manure piles. Plowing the hog lots will help to free them from the white grubs and the eggs of the round worm as well.

In selecting a medicinal treatment it is necessary to select such drugs as will destroy the worms and still not injure the hog to an appreciable degree. The following formula which was first used on the college herd by the Division of Veterinary Medicine and has since been recommended by the Animal Husbandry Department has given such satisfactory results that it is now considered advisable to publish it for the general use of hog raisers.

Santonin, eight grains;

Calomel, one grain;

Areca Nut, two drams;

Sodium Bicarbonate, one dram.

The above quantities are for one hog weighing 100 pounds and the quantity should be increased or decreased according to the size of the hog and multiplied by the number of hogs. The most satisfactory results are secured when the hogs are divided into lots of twenty or less and food should always be withheld for twenty-four hours. Then mix the worm powder thoroughly with some moist ground feed and give it in such a way that each hog will get its share of the medicine in the feed. Not too much feed should be used as it dilutes the medicine. This treatment may be repeated in three weeks if the worms are not all removed by the first administration, but usually one treatment is sufficient.

LUNG WORM OF SWINE.

The LUNG WORM OF SWINE (*Strongylus Paradoxus*) is a delicate white

or brownish thread like worm, one-half to one and one-quarter inches long. The entire life history of this worm is not quite clear but is probably similar to one of the lung worms in sheep in which case the eggs are expelled into water or moist earth and may remain alive for months. When conditions are favorable (warmth and moisture) they



Lung Worm in Lung of Hog (*Strongylus Paradoxus*)

undergo a moulting process and if dried up soon after this they can be preserved for a year or more without being killed. Therefore the worm is very resistant to drying and may enter the body with the dust by inhalation or with the food or drinking water. On cutting through the affected part of the lung the worms in the air passages are frequently sufficiently numerous to completely fill them.

SYMPTOMS.

The first symptom is a cough, noticed especially when the pig leaves the bed or following exercise or after eating. This cough is sometimes called whooping cough. In extreme cases there may be vomiting. Quite often the pig thrives and recovers, while in other cases there is unthriftiness, difficult breathing (thumps) which finally leads to death after a chronic course.

TREATMENT.

The most important part of the treatment is to keep the pigs in a growing healthy condition. New pastures and lots which do not receive drainage from the old ones should be provided and all possible precautions should be observed in keeping infested hogs from contaminating the new pastures. The hog houses should be thoroughly cleansed and disinfected, and the old pastures may be plowed and cultivated or used as a pasture for stock other than hogs. The medicinal treatment is as yet not satisfactory or practical.

TESTING SOILS IN LABORATORY AND FIELD

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE AND
THE MECHANIC ARTS

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Soils

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Ames, Iowa

TESTING SOILS IN THE LABORATORY AND FIELD

BY W. H. STEVENSON AND P. E. BROWN.

WHAT THE STATION CAN DO TO HELP THE FARMER.

The chief aim of the soils section of the Iowa Agricultural Experiment station is to help the farmer solve his soil problems. This is possible because the work of the section consists not only in the study of soil problems of statewide interest, but also in the application of the results of such general investigations to local conditions.

It may be said, therefore, that there are two distinct divisions of the soil work. First, there is the experimental or investigational part, which consists in the planning and carrying out of experiments on methods of soil treatment and soil management; and second, there is the advisory part. Through this latter function the soils section aims to keep in close touch with the farmers and to help them solve their local problems, often arranging special experiments to aid in the solving of them.

The experimental work in soils during the past few years has included the study of many important questions, chiefly, however, the rotation of crops, the use of fertilizing materials, the drainage of the soil, and the management of certain partially unproductive soils, such as gumbo, peat, alkali and "push" soils. In a general way it may be said that all effort has been directed toward securing the greatest crop production with the least soil depletion.

It is evident therefore that the section has material at hand which permits of authoritative statements along many lines of soil management. There are, of course, many questions which it is not yet possible to answer absolutely and completely, because anything like a complete study of the soils of the state will require years of labor and abundant facilities. In so far as investigations have led to conclusive evidence along certain lines, the section is ready and glad to make recommendations regarding the management and improvement of Iowa soils, and to do it free of charge.

In order to advise regarding the proper treatment of any soil it is necessary, however, that certain facts regarding the lay of the land, the crops grown, the fertilizers added, etc., be in the hands of the station men. It is not merely enough to send in a small sample of soil, although that, of course, is helpful in many cases. It is sug-

gested that the following questions be answered by every farmer who wishes advice. These answers and, if desirable, a sample of soil carefully taken, as will be described later, should be sent to the Soils Section of the Iowa Agricultural Experiment Station, Ames, Iowa.

Where is the land located?

How long has the land been under cultivation?

What system of cropping is practiced?

What rotation of crops is used?

What was the crop yield last year?

What was the crop yield the preceding year?

What crop yields the best?

What crop gives the poorest results?

Has inoculation been practiced for legumes?

Is the land level or rolling?

What is the depth of plowing?

Are there any peculiarities about the soil?

Is the land drained? How?

How much manure has been applied? When?

How much fertilizer has been added? When?

How much lime has been used? When?

WHAT THE STATION CANNOT DO.

Certain limitations are imposed upon the work of the soils section by the laws under which experiment stations were founded and by the size of the annual appropriations. The section cannot undertake to analyze samples of soil or fertilizers for private parties. Analyses of soils and fertilizers are expensive and tedious operations, and should all the members of the staff, the size of which is limited by the appropriations, spend their entire time on such work, only a small part of the samples annually received could be analyzed. Therefore such analyses are out of the question for financial reasons.

But there are further and more important reasons why such analyses are not made. In the first place, samples of soil taken at random without regard to their representative character may be so very local in nature that their analyses would be of practically no use to the farmer, and of absolutely no general value. Furthermore, complete chemical analyses of soils give only their total plant food content. Such analyses may show lack of nitrogen, phosphorus or potassium, or an abundance of these elements, but they give no idea of the rate at which they become available, and hence merely indicate the ability of the soil to support plant growth. For instance, nitrogen, phosphorus and potassium may be shown by chemical analyses to be present in abundant amounts, but an application of a nitrogenous, as phosphate, or a potassic fertilizer might yield astonishing returns. On the other hand, very small amounts of these constituents might be present and yet additional applications might give a very small, or even no increase and therefore represent an actual money loss.

The reason for this is simple. All plant food in the soil does not exist in a form available for plants. That is, it must be prepared for them just as human food is prepared in kitchens. The raw materials are acted upon by various agencies and changed into forms which are of use to plants. The bacteria may be called the cooks in charge of the plant kitchens. When these cooks are inefficient there is a decrease in the production of prepared food and the plants are inadequately fed. When the cooks go out on a strike, because of improper working conditions, such as lack of air, water, or food (organic matter), no food is prepared and the plants starve.

In all soils there is a certain relation between the raw food known as potential, or total plant food, and the prepared material, known as active or available plant food, and this relation is determined by the efficiency of the bacteria (the cooks). That efficiency is secured by keeping conditions in soils satisfactory for bacterial growth by providing the proper amount of air, maintaining the best moisture conditions, and supplying food material, or organic matter. These conditions may be kept right by proper tillage, drainage or irrigation, and the addition of manure.

Chemical analyses do not show whether or not conditions are right for bacterial activity. Chemical analyses, as has been pointed out, give only the total or potential plant food content of soils and hence merely indicate the needs of the soil, unless the total food supply is very small, in which case it is safe to assume that more should be added.

It has been well said that "the chief value of a chemical analysis is to serve as an absolute foundation upon which methods of soil treatment can be safely based for the adoption of systems of permanent soil enrichment, not for one crop or one year, but for progressive improvement."

The soils section is now working on a soil survey of the state and analyses are being made of many samples representing typical soil areas. These samples have been obtained with great care by the station men using the most accurate means of sampling, and they are representative of definite soil types. Thus, while it is impossible to analyze all the soils of the state, the composition of representative soil types may be ascertained and the soil areas mapped in detail. From these data and experimental results obtained on the different soil areas information will be available regarding the treatment advisable for any soil, the crops best adapted to it, and the best method of management.

These facts give all the information which the farmers need. The analyses of the typical soil areas give the approximate composition of their soils and the plant food deficiencies may be as closely determined as would be possible from chemical analysis of special samples.

In the case of abnormal soils, however, where no typical analyses are to be found, it may be advisable for the farmer to collect a sample of soil, as will be described, and have an analysis for nitrogen, phos-

phorus and potassium, and possibly for calcium and magnesium made by a commercial chemist.

Using the analysis as a basis, field tests should then be made to obtain definite information regarding the actual influence of different fertilizing materials.

COLLECTING SOIL SAMPLES.

In the few cases where samples of soil need to be taken, either to be sent to the station for examination or to be analyzed by a commercial chemist, care should be taken that they are representative of the entire field and not peculiar merely to the spot from which they were taken.

The places from which the samples are to be obtained need to be carefully cleaned of grass and other vegetation. About twenty or more different spots a few rods apart are chosen, all apparently representative of the soil type, and borings are made to the depth of plowing. These borings may be made by means of a regular soil auger, which is about 40 inches long and $1\frac{1}{2}$ inches in diameter, the kind used by the station men, or samples may be taken by means of a trowel or spade.

The borings or samplings are then thoroughly mixed and placed in a clean receptacle. A strong muslin sack may be used for mailing or expressing a sample of soil for an analysis or an inspection. The surface samples are usually taken from the surface to a depth of 6-2-3 inches. A second and a third sample are then taken in the same manner, one of the subsurface soil 6-2-3 inches to 20 inches, and one of the subsoil 20 inches to 40 inches.

It is quite essential that all samples be taken as suggested, for soil is very apt to be quite variable in composition and the samples should represent definite soil areas. If they are not representative the results of the analyses are of no value whatever.

SOME TESTS WHICH THE FARMER CAN MAKE.

From the results of the soil survey of the state, which has been mentioned, and the experimental data in connection with it, it will be possible to make many definite recommendations regarding profitable methods of soil treatment, but there are some tests of particular soils which the farmer can very readily make for himself.

ACIDITY.

In the first place the soil should be tested for acidity. Most crops will grow satisfactorily in acid soils, and many make no growth whatever.

There is a wide range in the sensitiveness of different crops to acid conditions, the legumes, such as clover and alfalfa, being most readily affected. Beneficial bacterial activities are also inhibited by

acidity and the change of insoluble plant food into a soluble form is restricted or absolutely prevented.

There are certain outward indications of soil activity which are quite evident to any farmer. For instance, if clover or timothy refuse to grow and red top and sorrel appears instead, the soil is usually in need of lime. The presence of moss, or the growth of red sorrel bluets, horsetails, or other similar weeds is evidence of a lack of lime in the soil.

There is, however, a definite test for soil acidity which may be made on any farm. It is known as the litmus paper test and is based on the power of acids to change blue litmus paper to red.

In order to make the test a small sample of soil, free from roots and grass, is put into a clear glass container like a water glass. Two or three strips of blue litmus paper are inserted in the soil so that they are half covered, care being taken that the portion in contact with the soil is not touched with the fingers. Pure water is then added carefully until the soil is thoroughly wet. The test is allowed to stand for several minutes and the paper removed and rinsed thoroughly. If the portion of it which was in contact with the soil has become red, the soil is acid and would be benefited by liming. The litmus paper for this test may be bought at any drug store.

That a thorough test for acidity may be made, samples of the surface soil and the subsoil should be taken from several different places in the field. If the soil is shown to be acid by this litmus paper test, then ground limestone should be applied. An application of 2,000 to 3,000 pounds per acre should be sufficient to remedy a moderate degree of acidity for most crops, but if the soil is shown to be strongly acid, and alfalfa or clover are to be seeded, 3,000 to 4,000 pounds per acre should be used.

By application of ground limestone not only is the acidity of some soils corrected, but heavy clay soils which are too wet and improperly aerated are opened up and made more fertile. Light sandy soils, also, which tend to lose valuable plant food by "burning out" and leaching and are apt to dry out too quickly are made more compact and thus more retentive of moisture and plant food.

The physical character of such soils therefore is improved and they are made more favorable for the growth of bacteria and indirectly for the growth of plants.

Finally the lime may remedy an actual deficiency in plant food, calcium. Alfalfa, for example, removes a large amount of calcium from the soil and the succeeding crop may suffer for lack of calcium.

Further information regarding the effects of lime, the losses from the soil, the kind to use, the method of application, etc., may be found in Circular No. 2, of the Iowa Agricultural Experiment Station.

CARBONATES.

Acid conditions cannot exist in a soil which contains an abundance of carbonates. A test therefore of the presence of carbonates will give

indications of the acidity of the soil. This test is based on the fact that acids attack carbonates with the liberation of carbon dioxide gas. Thus when soils containing carbonates are treated with hydrochloric acid there is a foaming or effervescence due to the rapid evolution of the gas. Conversely, if a soil is treated with hydrochloric acid and there is abundant foaming, evidence is at hand that carbonates are present in considerable amounts and the soil cannot be acid. If no foaming occurs then the soil may be acid or neutral.

To make the test, a little concentrated hydrochloric acid is poured on a small sample of moist soil in a clean dish or other receptacle. The extent of foaming is a rough indication of the amount of carbonates present in the soil.

A small amount of hydrochloric acid is all that is necessary to make a large number of tests and it may be easily secured at any drug store. Care should be taken that the acid is not brought into contact with the skin or clothing as bad burns may result. If any of it is accidentally spilled it should be washed off immediately.

Even although negative results are secured in the surface soil, tests should be made of the subsoil as the presence of carbonates there would be of considerable importance particularly in the case of deep rooted crops.

PHYSICAL CONDITIONS.

It is hardly necessary to emphasize the need of proper methods of tillage and cultivation to keep the soil in proper physical condition. Every farmer knows that he may conserve the moisture in his soil during a dry season by keeping it cultivated. The value of the proper preparation of the seed bed for all crops is also a matter of common knowledge. Proper plowing and disking, the killing of weeds, etc., are recognized as essential for satisfactory crop growth.

If the soil is open and porous, dries out too rapidly and is deficient in organic matter, as is often the case due to the "burning out" of this important soil constituent, then applications of barnyard manure or green manure should be made and lime applied. Not only is the physical structure of the soil improved by such treatment, but satisfactory conditions are offered for bacterial activity and there is consequently a sufficient production of plant food to insure good crop growth. The practice of green manuring to build up light soils cannot be too strongly emphasized.

Further information regarding green manure crops and methods of green manuring may be found in Circular No. 10, of the Iowa Agricultural Experiment Station. If the soil is heavy and cold and too much moisture is apt to be present, applications of lime will help, and proper drainage should be provided, preferably by the use of tile drains.

PRESENCE OF PLANT FOOD.

The presence of available plant food in the necessary amount is one of the chief requisites for the best growth of crops. The amounts in available form of the various elements which are necessary for the

growth of plants cannot be ascertained by chemical analyses but must be determined by field experiments such as are described farther on in this circular.

As has been pointed out, chemical analyses merely give indications of plant food deficiencies, showing as they do the total plant food present.

Of the ten chemical elements which have been found to be essential for the growth of plants, five are supplied in sufficient amounts either from the air or soil, and need not be applied to the soil. These five elements are carbon, hydrogen, oxygen, sulphur and iron.

Nitrogen, phosphorus, potassium, calcium and magnesium may be lacking in soils, however, and if lacking, crop yields will be deficient. The two latter elements may be supplied by application of lime as calcic or dolomitic limestone, as has already been shown. If a soil is acid these elements are probably lacking.

NITROGEN.

A deficiency in nitrogen in a soil may be safely assumed if there is a lack of humus or organic matter present. Conversely, if a soil is dark in color it is well supplied with humus and will contain a supply of nitrogen, although the absence of satisfactory physical conditions may prevent the proper production of soluble nitrates. In such a case the adjustment of the physical conditions would prove more profitable than an application of sodium nitrate or any other nitrogenous fertilizer.

When soils are deficient in humus and nitrogen, applications of barnyard manure should be made and leguminous crops should be grown and used as green manure. Thus the organic matter and nitrogen content are both increased and the use of any other nitrogenous material is unnecessary for the production of common farm crops such as corn, oats and hay.

In some particular instances it might be worth while to make a small application of sodium nitrate to act as a stimulant to start and encourage the growth of a crop, but in general farming the use of commercial nitrogenous fertilizers on Iowa soils is unprofitable and unnecessary.

In market gardening, however, the application of nitrogenous or other artificial fertilizers is often of considerable value as here abundance of available plant food is necessary for forcing the crops.

POTASSIUM.

The potassium content of most soils is considerably greater than the nitrogen or phosphorus content and there is much less danger of a deficiency of that element. That is, the *total* amount of potassium in soils is large and if conditions are satisfactory for the transformation of the inactive into the active forms, applications of potassium fertilizers are hardly necessary.

Thus, if the humus content of the soil is high, its reaction is not

acid, and if the proper methods of tillage are practiced, the bacterial activities which accomplish the solution of unavailable plant food constituents are facilitated and abundant potassium in proper form is offered to the crop. On soils, however, which show a deficiency in total potassium as is true of some poor, light soils, and many peat soils, especially those which are deep and are underlain with rock or sand, then an application of kainit, potassium chloride or potassium sulphate is to be advocated.

PHOSPHORUS.

Phosphorus is the element which is most apt to be deficient in soils, not only in available form but also in insoluble compounds. According to many analyses there is less than 2,000 lbs. of phosphorus per acre to a depth of 6-23 inches in Iowa soils. Comparing this with over 30,000 lbs. of potassium per acre to the same depth, it is evident that there is more danger of a phosphorus deficiency in the soils of the state.

This deficiency may be remedied by applying phosphorus to the soil in one of three forms: as fine ground natural rock phosphate, as steamed bone meal, or as acid phosphate. The latter material carries the phosphorus in a form immediately available for plant food, while in the other cases it occurs in an insoluble form and must be transformed to be available. The advocates of rock phosphate recommend, however, that it be applied with barnyard manure or green manure in order that bacterial activities may be enhanced by the latter materials and a more rapid transformation of the phosphorus compounds may occur. They contend also that as the soluble phosphates are transformed into an insoluble form in the soil, when not immediately assimilated, it is of no particular value to use the soluble form. While this change of the soluble form into insoluble does occur in the soil, one important point should not be overlooked—when the soluble material is added to the soil it is immediately dissolved and uniformly diffused through the soil.

Thus, after the change into insoluble form occurs the phosphate is in such physical shape that the bacterial action reproducing the soluble material is considerably greater than it is on the insoluble rock itself.

The rock is much cheaper and hence its use may seem advisable for financial reasons, but it is still a mooted question whether it is not more profitable to apply a soluble phosphate which unquestionably gives quicker returns and probably larger yields even although perhaps not as great percentage returns for the money invested, than to bury a large quantity of rock phosphate in the soil where it becomes slowly available.

The Station is not prepared to make definite recommendations on this point, and if they desire, farmers may test and compare the use of soluble and insoluble phosphorus fertilizers.

FIELD TESTS TO DETERMINE FERTILIZER REQUIREMENTS OF SOIL.

Farmers generally recognize the fact that soils differ in productive power. Sometimes soils which differ markedly from each other are found on the same farm or even in the same field.

In many cases the best soil on the farm is not as fertile as it should be, or some portion of the farm is notably unproductive. The farmer may desire therefore to test his soils in a practical manner in order to determine the effect of nitrogen, phosphorus, lime or some other fertilizing material on the crop yields.

A fertility test that has been thoroughly tried out and that includes the application of substances supplying the elements of plant food which are apt to be deficient in Iowa soils, can be made by any thoughtful and careful farmer in the manner described in the following paragraphs:

ESSENTIALS IN A TEST.

In the first place, the soil on which the experimental plots are to be located should be truly representative of the soil which it is proposed to test. If this is not the case the experiments will be of little value and they may even prove misleading and induce the land owner to adopt a system of management which will not give satisfactory results.

Again, the land which is devoted to the experimental plots should be kept, through the years, under a definite system of crop rotation. This is essential because a good rotation system is the basis of nearly every satisfactory soil management scheme. No particular type of rotation will, of course, be used in all sections of the state. Each farmer will be compelled to choose a rotation which he believes will give the best results under existing labor, market and soil conditions.

An excellent rotation for many sections of Iowa is the following:

- First year—corn,
- Second year—corn,
- Third year—oats or wheat,
- Fourth year—clover.

This rotation keeps one-half of the cultivated portion of the farm in corn. Many grain farmers favor this plan because corn is classed as the chief "money" crop in the state, while the live stock farmers prefer it because the corn crop most nearly meets the requirements of their feeding operations.

Below is given another good rotation which is especially adapted to the southern and western portions of the state:

- First year—corn,
- Second year—oats,
- Third year—clover,
- Fourth year—winter wheat.

This rotation includes winter wheat and therefore will prove particularly satisfactory to the large number of Iowa farmers who are now growing this crop much more extensively than in former years. Wheat is an excellent crop in a fertility test because it shows quite definitely in yield and quality the effect of soil treatment.

Either of the rotations referred to above may be extended to cover a five or six year period by seeding timothy with the clover and using the crop for pasture or meadow.

LOCATING AND MARKING OUT THE PLOTS.

After a rotation has been decided upon a series of ten plots should be marked off in that portion of the field which is most nearly representative of the soil which is to be tested.

The plots should all be of the same size. On the average, farm plots which contain one acre each will probably be found to be most satisfactory. They may, however, contain one-tenth, one-quarter or one-half of an acre each. The size of the plot must necessarily be determined by local conditions. A long and narrow plot is usually preferred; for example, a one-tenth acre plot which is two rods wide and eight rods long, and plots of other sizes in proportion. It is advisable to separate plots by a division strip seven feet wide. A strip of this width will accommodate two rows of corn, or one seven-foot drill.

A satisfactory plan for showing the location of each plot is worked out by setting a stake in the fence row adjacent to the fence, to mark the outside corner of the first plot. The second stake should then be set in line with the corner stake at such a distance as marks off the exact width of the first plot. The third stake should be placed seven feet beyond the second, and thus show the location of the division strip between the first and second plots. By following this plan the exact location of each plot in the series may be shown.

A diagram drawn to scale on paper, should be made of the field plots which will show the location of the soil under investigation, the exact length and width of each plot, the width of the division strips, and the soil treatments. In connection with this diagram, there should be a record book, in which should be entered the dates of all operations and other items bearing upon the progress of the experiment. It is never advisable to trust to memory or to field stakes for the plan of the experiment.

RECORD OF THE EXPERIMENT.

The following form will be found convenient for keeping the final data of a field experiment which is continued from year to year:

FORM FOR PLOT EXPERIMENT DATA.

Plot	Soil Treatment Applied	Corn 1914	Corn 1915	Oats 1916	Clover 1917	Corn 1918	Corn 1919	Oats 1920
		Bushels or tons per acre						
1	None -----	50						
2	Manure -----	60						
3	Manure and lime	61						
4	Manure, lime and phosphorus ---	65						
5	None -----	48						
6	Crop residues----	58						
7	Crop residues and lime -----	60						
8	Crop residues, lime and phos- phorus -----	63						
9	Crop residues, lime, phosphor- us and potas- sium -----	65						
10	None -----	50						

Given herewith is an outline of one of the simplest and most practical series of plot experiments, and it is recommended for all normal types of Iowa soils on which common farm crops are grown.

The series of soil treatments listed below really includes two distinct systems of farming. For instance, the treatments recommended for plots one to four inclusive, represent a live stock system of soil management, while plots five to eight inclusive, represent a grain farming system. It is suggested that any farmer who does not wish to use as many as ten plots may confine his experiments to either the live stock or the grain system. If this is done, in some cases it may be advisable to include the treatment suggested for plot nine, and thus make the test include potassium.

PLAN FOR PLOT EXPERIMENTS.

a—Fertility test. b—Live stock system. c—Grain farming system.

Plot No.		Soil Treatment
a	b	1-----None.
		2-----Manure.
		3-----Manure and limestone.
		4-----Manure, limestone and phosphorus.
	c	5-----None.
		6-----Crop residues.
		7-----Crop residues and limestone.
		8-----Crop residues, limestone and phosphorus.
		9-----Crop residues, limestone, phosphorus and potassium.
		10-----None.

DETAILS OF EXPERIMENT PLAN.

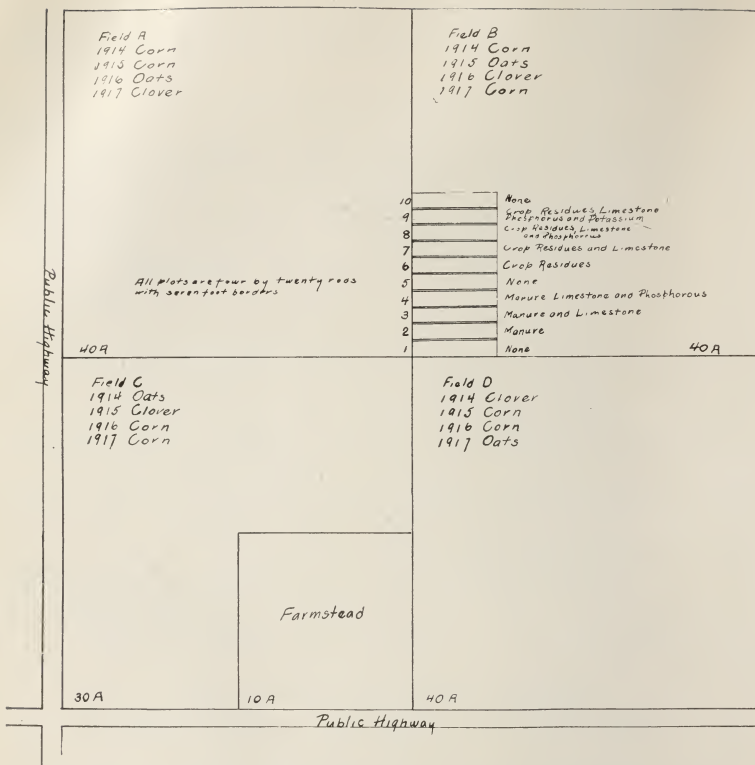
The following explanations regarding the details of this plan for plot experiments in the field should be carefully noted:

1. Manure of good quality, but fairly representative of that commonly produced on the farm, should be applied at the rate of eight or ten tons per acre, once in a four year rotation and in proportionate amounts for rotations which cover a shorter or longer period of time. When it is possible to do so, the manure should be put on the clover field and plowed under for corn the following year.

2. Ground limestone or limestone screenings should be applied to the land after it has been plowed, at the rate of two or three tons per acre, once in a four year rotation. The application of lime may be made at any convenient time of the year.

3. Phosphorus may be applied in finely ground rock phosphate, steamed bone meal or acid phosphate. The rock should be used at the rate of 2,000 pounds per acre, the steamed bone meal at the rate of 800 pounds per acre, and the acid phosphate at the rate of 300 to 400 pounds per acre. These applications are made but once in a four year rotation.

4. The soil treatment recommended for plot 6, is designated as "crop residues". This treatment should be understood to mean that all products except the grain or seed which are sold in grain farming, shall



SUGGESTIVE PLAN FOR LAYING OUT SOIL TEST EXPERIMENT PLOTS

be returned to the land and used as fertilizers. The details of this procedure are as follows:

A. The clover should be clipped once or twice somewhat earlier than the first cutting for hay would ordinarily take place. The clipped material should be left on the land to be plowed under later.

Seed should be taken from the second crop if there is a yield which will justify the expense of the harvest. There is a strong demand in this state for clover seed of good quality and the prices are such as to make yields of even one or two bushels per acre quite profitable.

B. The corn stalks should be cut with a disk or stalk cutter and plowed under.

C. The threshed straw from small grain and clover should be returned to the land. This may be done at some convenient time. Often the straw is stacked in a feed yard for a few months and then applied as a fertilizer. This plan affords the work horses on the farm some feed during the winter and permits the straw to decay to some extent, putting it in a better condition to handle.

5. It should be noted that neither crop residues nor any other fertilizing material are to be applied to plots 1, 5 and 10. All crops are to be removed from these plots, and nothing returned.

6. Potassium may be applied in potassium chloride, potassium sulphate or kainit. The chloride and sulphate should be used at the rate of 200 to 300 pounds per acre, and the kainit at the rate of 1,000 pounds per acre, once in a four year rotation.

NOTES.

In order to give some idea of the cost of carrying out the tests which have been described, the following notes are appended.

It is recognized, of course, that the cost of fertilizers will vary somewhat from year to year and consequently only the approximate cost is given here. The freight rates on these materials are also exceedingly variable and must be considered in estimating their total cost.

The quotations given here are the average cost of the fertilizers independent of the freight charges.

Fertilizing materials may be purchased from nearly all the leading packing firms and from dealers in commercial fertilizers. The advertisements of many of these firms will be found in agricultural papers and trade journals.

ROCK PHOSPHATE.

Raw rock phosphate finely ground, for application to the soil, contains from 10 to 14 per cent of phosphorus and costs from \$3.50 to \$5.00 per ton, f. o. b. cars, at the Tennessee mines. The freight to various points in Iowa will bring the cost of the rock up to \$7.50 to \$10.00 per ton, in carload lots.

Rock phosphate is quite variable in composition, both physically and chemically and its value is considerably modified by small differences.

It should be so finely ground that 90 per cent of the material can be washed through a sieve of 100 meshes per inch. The percentage of fine material may easily be tested by washing a certain amount through a sieve and drying and weighing the residue.

The phosphorus occurs in the rock mainly as calcium phosphate and the percentage of this compound present therefore determines the purity of the material. An analysis showing only 50 per cent of calcium phosphate present means that 50 per cent of the material consists of impurities.

Small differences in the chemical composition of the rock should appear in the cost of the same. It would be advisable, therefore, to have an analysis made by a commercial chemist in order not to pay more for the material than its composition would warrant. This is worth while even though it costs two or three dollars, as a difference of only two per cent in composition might mean a loss of 30 or 40 dollars on a carload lot.

Care should be observed in taking this sample that it be representative of the entire carload lot. Fifty or sixty small samples taken from different places in the car should be thoroughly mixed and about a pound sent to a chemist for analysis.

ACID PHOSPHATE.

Acid phosphate is made by treating the raw ground rock with acid which changes the insoluble calcium phosphate into a soluble form. The material as it is placed on the market is in a finely ground form and contains in addition to the soluble calcium phosphate also some calcium sulphate, a product of the treatment of the rock.

Acid phosphate contains about 14 per cent of available phosphoric acid and costs from \$14.00 to \$16.00 per ton f. o. b. cars.

BONE MEAL.

Steamed bone meal contains about 12½ per cent of phosphorus and may be obtained for \$25 to \$30 per ton f. o. b. cars in carload lots.

POTASSIUM SALTS.

Muriate of potash, the trade name for potassium chloride, and potassium sulphate contain about 40 per cent of potassium and cost from \$40 to \$50 per ton f. o. b. cars, while kainit, containing potassium sulphate and some magnesium sulphate, magnesium chloride and sodium chloride, has about 10 per cent potassium and may be obtained for from \$12 to \$15 per ton f. o. b. cars.

GROUND LIMESTONE OR LIMESTONE SCREENINGS.

Ground limestone or limestone screenings may be obtained from the following companies:

McManus & Tucker, Keokuk, Iowa.
 Ellsworth Stone Co., Iowa Falls, Iowa.
 Peru Stone and Cement Co., East Peru, Iowa.
 Dolese Bros., 1310 Otis Bldg., Chicago, Ill.
 Fort Dodge Portland Cement Co., Gilmore City, Iowa.
 Burlington Quarry Co., 19 S. 7th St., Keokuk, Iowa.
 J. A. Green and Sons, Stone City, Iowa.
 H. Dearborn's Sons, Stone City, Iowa.
 F. Erickson & Co., Stone City, Iowa.
 Linwood Quarries Co., Davenport, Iowa.
 Bartlett & McFarland, Waterloo, Iowa.
 B. N. Arquitt & Sons, Farley, Iowa.
 Charles Chilton, Ottumwa, Iowa.
 John Boland, Bettendorf, Iowa.
 John Rowen, Stone City, Iowa.
 Quimby Stone and Fuel Co., Mason City, Iowa.

Prices varying from 15 cents to \$1.15 per ton are charged by these concerns f. o. b. their quarries. Some of the material is finely ground limestone and some limestone screenings. For the best results it may be said that the limestone should consist of at least 60 to 70 per cent powder.

CARE, FEED AND MANAGEMENT OF THE DAIRY HERD



AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Dairy Husbandry Section

Ames, Iowa

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CARE, FEED AND MANAGEMENT OF THE DAIRY HERD

BY H. H. KILDEE.

Dairy farming is rapidly increasing in popularity in almost every section of Iowa because the dairy cow has characteristics which not only give her present popularity but insure it for all time to come.

One of the chief advantages of dairy farming is that the dairy cow fits admirably in diversified and intensive farming where the farmer strives to produce the greatest possible income from a small acreage and yet retain the fertility of his farm. In Europe, the dairy cow is the foundation of agriculture in the most prosperous countries, such as Denmark and Holland. Proof that she is adapted to high priced land may be found on the Jersey Isle, where ground rentals run from \$50 to \$60 per acre annually, and in Holland, where farms sell up to \$1000 per acre. In both places land is used largely for dairy farming. In Iowa, land is constantly getting dearer, yet by using silos and soiling crops, tilling the farm intensively and purchasing some concentrated nitrogenous foods, it is not out of the question to keep one cow to each acre of ground, and even more under certain conditions. Poultry and swine raising may be carried on most successfully on the dairy farm because of the feeding value of the skim milk, a valuable by-product.

DAIRY FARMING INCREASES SOIL FERTILITY.

Dairy farms increase rather than decrease in soil fertility. A ton of corn worth from \$10 to \$14 removes \$8.60 worth of plant food. A ton of butter worth over \$600 removes only 64 cents' worth of plant food. A dairy cow weighing 1,000 pounds voids 11 to 13 tons of solid and liquid manure each year, which is worth about \$25 for increasing crop yields. Many farms which were formerly very poor from the fertility standpoint have been built up in a few years through feeding the crops and purchased supplementary feeds to dairy cows.

Economy of production is another factor in favor of the dairy cow. Quoting Professor W. A. Henry, "Not only is dairying the leading animal industry of our country at this time, but so it must continue indefinitely, for the reason that the cow is a more economical producer of food for human beings than is the ox or pig." And again, "for each 100 pounds of digestible nutrients consumed, the dairy cow yields about six times as much edible solids in her milk as the beef steer or mutton sheep in its carcass."

In addition to being an economical producer, the dairy cow is a more dependable source of profit than the beef steer, because her products are but slightly affected by market fluctuations and because she is a continuous source of revenue, for the cream or milk checks come in at frequent and regular intervals. Then, too, there is a greatly increased demand for dairy products and for grade and pure bred dairy cattle, not only in the United States, but also China, Japan, New Zealand, South America and elsewhere.

One of the strongest arguments brought against dairy farming is that it is often rather difficult to secure competent help. It will

be noticed, however, that the man who makes the milking a part of the day's work instead of attaching it as something in addition to a normal day's work, has little or no difficulty on this score. It is not the milking itself that many hired men and boys object to, but that on many farms they are compelled to do this work early in the morning and late at night in addition to a full day's work in the field.

IOWA'S AVERAGE PRODUCTION LOW.

In spite of the fact that dairy cows as a class are very economical producers, many cows milked in Iowa at the present time do not pay for their feed, in milk and butter fat. It is safe to say that the average amount of butter fat produced by the cows in Iowa does not exceed 140 pounds per cow per year. At the same time there are many animals in the state that have produced over 500 pounds, several have exceeded 700 pounds, a few 800 pounds and the Guernsey cow, Dairy Maid of Pinehurst, produced 910.67 pounds of butter fat in one year. The world's record for all breeds is 1058.34 pounds of butter fat, produced by the Holstein cow, Banostine Belle DeKol. Another cow of the same breed, Creamelle Vale, holds the world's milk record for one year, with 29,591 pounds of milk. Considering the fact that the cost of keeping a cow is not in proportion to her production, for poor, unprofitable cows in many cases are fed the same rations as large and profitable producers in the same herd, it can readily be appreciated that the present low average production is unsound and unbusinesslike.

This condition is due both to inferior cows and to improper care, feed and management of the cows. Either one or both factors may



Fig. 1. Four pure bred Holstein cows owned by Iowa State College. Average record for one year 16660.3 pounds milk, 557.57 pounds butter fat, average test 3.34%, average net income for butter fat after deducting cost of feed, \$110.21 per cow.

play an important part in cutting down profits. Thousands of cows kept on Iowa farms are not returning a profit simply because they are improperly fed and managed, and still larger numbers of so-called dairy cows are not paying for their feed and could not, even though given the very best of care and feed. The term dairy cow, as used in this state at the present time, is a misnomer, as about one-third of these so-called dairy cows have practically nothing in common with the typical dairy cow, either in conformation or productive ability. Nearly one-half of the remaining cows are so fed and managed that they produce about one-half of what they are capable of producing if properly cared for.

An experiment which is being carried on at the Iowa State college dairy farm to determine the effect of feed and environment upon amount of milk and butter fat produced by scrub cows brought from an isolated region in Arkansas is demonstrating that the amount produced, and consequently the profit returned, is materially influenced by the feed and management. Heifers out of these scrub cows and by pure bred dairy bulls are in many cases producing much more milk and butter fat, as two year olds, than their dams have produced as mature animals.

HOW ONE IOWA HERD IMPROVED.

The following records made by the herd of Peder Pedersen & Son in the Benson Cow Testing association in three consecutive years is especially interesting and valuable in this connection, as it shows what can be accomplished on the farm by keeping records, weeding out the poor cows and by proper feeding and management.

	Average Milk per Cow		Average Butter Fat per Cow	Net inc'me per cow over cost of feed
1911	5665 pounds	-----	207.7	\$ 22.12
	Largest net income cow in herd	-----		54.22
1912	7060 pounds	-----	251.9	53.96
	Largest net income cow in herd	-----		106.30
1913	9697.47 pounds (for the year)	-----	341.98	75.00
	Estimate for each of two largest net income cows	-----		144.00

The increase in production and in the net returns for butter fat, after deducting the cost of feed, in this herd in the course of three years is remarkable and was brought about by use of a pure bred sire, weeding out the inferior cows and giving the remaining ones better care and feed. This herd was made up of grades and a few pure bred Holsteins and the number of cows remained about the same during the three years reported.

THE DAIRYMAN A BUSINESS MAN.

The successful dairyman is not only a farmer and breeder, but, in the true sense of the word, he is a business man from the commercial standpoint, and a producer from the manufacturer's standpoint. He breeds, feeds and selects his cows, each upon its individual merits, for the purpose of converting the raw materials grown on the farm, in the form of grains and grasses, into a

finished commodity of commerce—milk and butter fat. The success of a manufacturer of shoes is determined by his ability to turn out a large number of shoes of good quality, such as will command a good price on the market, at a low cost of production. This is equally true of the producer of butter fat and milk. The price per pound of the commodity he produces is determined by its quality. Quality is determined by richness, color and cleanliness.

Not only is the quality and price per pound important, but also the quantity produced and the cost of production. Many cows yield milk extremely rich in quality or butter fat but give such a small amount that they do not pay for the food consumed. Others give a comparatively large amount of milk but so low in its butter fat content that they also do not pay for their feed and keep. The profitable butter fat machine then may readily be summed up as one that has the ability and capacity to produce from a minimum food supply a maximum amount of milk rich in butter fat content.

SELECTION OF COWS.

Extreme care is necessary in selecting cows, for no amount of skill in feeding and handling will stimulate a profit from a truly poor cow. A good dairy cow is one with a large capacity for using food above the maintenance requirement and one that uses this food for milk production. In determining the most desirable breed, one must consult his own likes and dislikes first. The man who likes a Holstein cow and dislikes a Jersey will be more successful with the former.

Conditions on the farm and the demands of its market need to be studied before selecting any breed. Jerseys and Guernseys are noted for their high per cent of butter fat, and their economy of butter fat production, especially under intensive farming conditions. The Guernseys in particular are known for the excellent color of their milk and butter fat. Holsteins and Ayrshires are noted for a larger flow of milk which is lower in per cent of fat. The Holsteins are very popular with Iowa farmers, because they are large, rugged and able to use large quantities of farm grown feeds in the manufacture of milk and butter fat, the milk being very valuable in raising calves, pigs and chickens. The Ayrshire breed is noted for its ruggedness and its rustling ability and yields a fair quantity of milk and butter fat.

As a matter of fact, however, the breed is of less importance in selecting the cow than is individuality, for in every breed there are good individuals and poor individuals. It is important, not only that the breed, but that the strain or family represented be noted for large and economical production of milk and butter fat. Experience has taught that form and function go hand in hand, so it is of utmost importance to demand dairy cows of proper form and type. There are, however, many exceptions to this rule, so that the performance of a cow through a period of lactation and the performance of her ancestors, especially her paternal grand dam, should have a great deal to do with her selection.

As a rule, sons of great producing cows are more likely to beget large producing daughters than are great producing cows them-

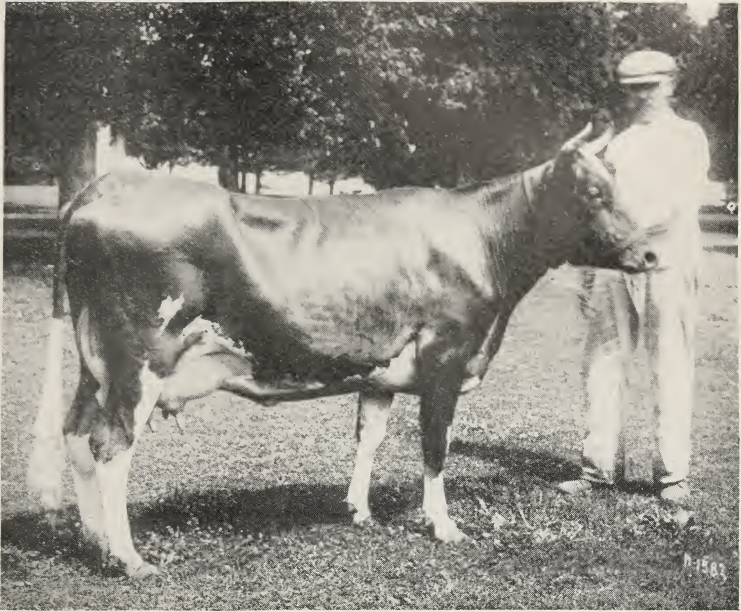


Fig. 2. Rouge II of the Brickfield, owned by Iowa State College. Has a year's record of 10,963 pounds of milk and 612.53 pounds of butter fat. World's record for a 2½ year old imported Guernsey.

selves. This illustrates the fact that cows need not necessarily be pure bred for a buyer or dairyman to take advantage of pedigree. Every cow has a pedigree, but not all pedigrees are on paper. In view of this fact, in selecting grade cows look up and consider the performance of dams as far back as they can be found.

Many buyers wisely use the Babcock test and scales in making their selections. By their use it is possible to determine the exact number of pounds of milk and butter fat produced by an animal. By noting whether she is advanced in her period of lactation and what her care and feed have been, the buyer can come closer to judging her real value as a milk and butter making machine than by any study of mere outward appearance. It has been truly said that the inside of a cow is the darkest place on earth and that, therefore, outward appearances are very deceitful. The scales and the Babcock test are the best guides, particularly the more accurate yearly tests which are to be emphasized rather than short tests.

Beginners in dairy farming should gain their experience and establish their reputation by starting in with grade cows and a pure bred bull. Later, by purchasing one or two excellent cows from time to time, they may get gradually started in pure bred. By keeping a record of the production of each cow and noting the relative cost of production much can be accomplished in a few

years. As former Governor Hoard said: "It is better to grow into dairy farming than to go into it."

SELECTION OF BULLS.

In selecting bulls to head the herd it is needless to say that only pure bred sires should be used.

Breed type and individual characteristics are entitled to due consideration, yet it is difficult to prophesy by the outward looks and appearance of a dairy bull what sort of calves he will beget from a producing standpoint. More attention should be given to the performance of his female ancestors, and especially his dam. A great producing cow is very likely to reproduce her characteristics through her sons, so by all means, after careful study of the bull himself, his dam should be investigated—study her form, milk producing machinery, and learn her record of performance. Many of the best breeders of dairy cattle select bulls almost entirely on the individuality and performance of the dams. However, the individuality of the bull himself is important also.

As for age, it is safe to say better results will be attained by buying mature, tried bulls, although this is not the rule usually followed. Bulls capable of begetting useful daughters are plenti-

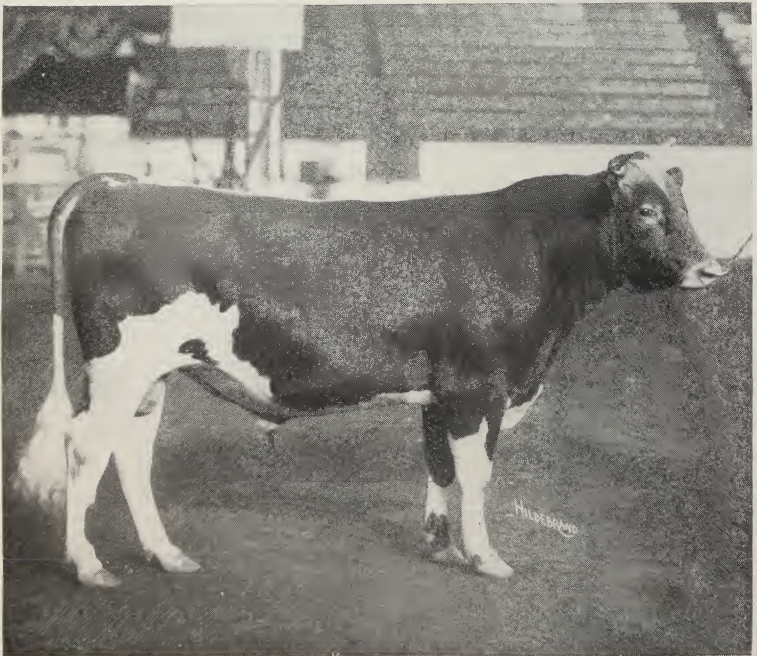


Fig. 3. Imp. Rouge II's Son, owned by Iowa State College. First prize two year old Guernsey bull at 1912 National Dairy Show. A son of Rouge II of the Brickfield.

ful, but those capable of begetting daughters that are phenomenal workers are few indeed, and the majority of these are lost before their full worth has been determined.

In selecting a bull to head the herd there must always be borne in mind the old saying, "The bull is half the herd." Much data is at hand showing the great difference that exists between dairy bulls in their ability to sire heavy producing heifers and a good dairy sire that will raise the average production of the herd 50 to 100 pounds of butter fat is a bargain at almost any price, while a so-called "cheap" bull may be a source of great loss.

In building up the dairy herd and selecting animals, extreme care is necessary to guard against disease, and especially the most common disease among them, tuberculosis. In buying animals, buy them subject to the tuberculin test, which should be made by a reliable veterinarian, who should give the buyer a certificate stating the temperature before and after the injection of the tuberculin. Reject all animals that react when conditions are known to be normal. Never allow an animal known to be infected with tuberculosis to step on the farm. All animals purchased, even though accompanied by a health certificate, should be isolated and tested again after they have been on the farm ninety days.

Contagious abortion is also very prevalent on dairy farms and much precaution must be exercised to guard against buying animals that will bring the germs of this destructive disease to the farm. In dealing with scrupulous breeders their word will generally suffice, but in all cases it is wise to isolate the new animals brought to the farm.

SELECTION OF FEED-STUFFS.

In securing the lowest possible cost of production, and ultimately the largest profit, from the herd, the proper selection of feeds is important. The primary object of the feeder, in all cases, is the maximum production of milk for least expenditure of feed. While each feed stuff is fairly uniform, so far as nutrient content, effect on the system and palatability are concerned, it is impossible to recommend a particular ration which will prove most economical and efficient at all times, because feed stuffs vary in price in different seasons and localities, and also because the feed requirements may vary with each individual cow.

The general requirements which should be met by rations for dairy cows are as follows: Palatability, variety, bulk, succulence, balance of nutrients, proper effect upon the system and economy.

Palatability is a factor of great importance, for, no matter how good the ration is from the standpoint of digestible nutrients contained, the best results can not be expected unless it appeals to the cow's appetite. To secure this palatability, feeds of good quality liked by the cow should be fed in a clean manger. All grains, such as oats, barley and corn, give best results when ground.

A cow soon tires of a ration made up of but one or two feeds and as radical or frequent changes in the ration are not conducive to the best results, it is important that feeds be so combined in the ration as to give variety. This variety is essential for the

dairy cow because, unlike the beef steer, she is on feed for a long period and for successive periods.

Bulk is required to help make digestion in the roomy digestive tract as thorough as possible; moreover, the bulky feeds grown upon the farm are the cheapest feeds. When bulk is lacking the digestive juices do not act as thoroughly upon the small, compact food mass and all the digestible nutrients cannot be utilized. This bulk is obtained not only through feeding alfalfa and clover hays and corn silage, but also by making the grain ration rather bulky. Corn and cob meal, ground oats and bran are bulky and all are good for the dairy cow.

Succulent feeds are very essential in profitable milk production. During the summer months succulence may be obtained from pasture grass, until the hot, dry weather makes it necessary to add corn silage or soiling crops. For winter feeding, corn silage is the most economical source of succulence under most farm conditions. Succulence is needed partly because the dairy cow is producing a product high in per cent of water, and partly because it has a good effect upon her system.

WHAT "BALANCE" MEANS.

By balance of nutrients, is meant a proper proportion between the digestible nutrients, protein, carbohydrates, fats and ash. The best combination will vary with the individual cow, the quantity and quality of milk she gives, the prices of feed stuffs, and her condition as to whether she is pregnant or not. Cows that have a tendency to become too fleshy need less carbohydrates and more protein in proportion, and cows with the opposite tendency more carbohydrates. As milk contains relatively large amounts of protein, fat and ash, the ration fed should carry a liberal supply of these nutrients so that the cow will not have to draw from her own body to make up a deficit. At the Wisconsin Experiment station it was found that in 110 days a dairy cow, fed a liberal ration yet one deficient in lime, gave up 25 per cent. of all the line of her skeleton. Similar results have been secured where cows have been fed rations sufficient only to maintain their bodies and not for milk production. Body tissue is sacrificed in order that the cow may secrete milk. Many of the cows on the Iowa farm today are doing this same thing. They produce milk in fair quantities for a few months after calving, not because of the ration made up solely of ear corn, timothy hay and corn stalks, but in spite of it. However, after they have drawn upon their own bodies as long as they can they rapidly decline in milk flow after five or six months. In many cases this lack of persistency is due to inherited characteristics as well as to failure to feed especially for milk production.

The proper effect of feeds upon the digestive system can be secured by a study of the characteristics and influence of different feeds. It is important to consider whether the feed or combination of feeds will have a cooling, laxative effect upon the digestive tract, or whether it will be heating and constipating.

The ration must be economical. In selecting feed stuffs, thought must be given to the relative values of different feed stuffs as well



Fig. 4. An excellent young bull of each of the four leading dairy breeds. Owned by Iowa State College.

as to their price per pound. Home grown feeds should be used so far as practicable. Where the dairy farm produces clover, alfalfa and oat and pea hays a large amount of the only nutrient the Iowa farmer needs to buy, protein, may be secured cheaply.

CHARACTERISTICS OF ECONOMICAL IOWA FEEDS.

The characteristics of the feeds which are most economical and efficient for the Iowa dairy farmer are given herewith:

Corn: In the corn belt corn must form the basis of the economical ration because it is the cheapest source of the energy supplying carbohydrates or starchy materials. However, it is necessary that feeds rich in protein and ash be fed with it for best results. The too common practice of feeding only timothy hay and corn fodder to milk cows is bad, as it keeps many cows from making a good record and returning a profit. In winter feeding corn may be fed in the form of corn and cob meal, as corn and cob meal is usually equal, pound for pound, to corn meal or corn chop when fed to dairy cows. This is due to the fact that the cob present adds bulk and by separating the starchy particles insures more complete digestion. In summer feeding cracked corn is usually considered preferable, because the cow is getting a great deal of bulky grass.

AVERAGE DIGESTIBLE* NUTRIENT CONTENT OF LEADING DAIRY FEEDSTUFFS
(Taken from Henry's Feeds and Feeding.)

Feeds	Total Dry Matter in 100 Lbs.	Total Digestible Nu- trients in 100 Lbs.			Total Ash in 100 Lbs.	Weight per Quart
		Pro- tein	Carbo- hydr'te	Fat		
Concentrates						
Corn, whole -----	89.4	7.8	66.8	4.3	1.5	1.7
Corn meal -----	85.0	6.7	64.3	3.5	1.4	1.4
Corn and meal cob -----	84.9	4.4	60.0	2.9	1.5	1.3
Gluten feed -----	90.8	21.3	52.8	2.9	2.0	1.3
Gluten meal -----	90.5	29.7	42.5	6.1	1.5	1.7
Corn bran -----	90.6	6.0	52.5	4.8	1.2	-----
Wheat, whole -----	89.5	8.8	67.5	1.5	1.8	1.9
Wheat, bran -----	88.1	11.9	42.0	2.5	5.8	.5
Wheat shorts -----	88.8	13.0	45.7	4.5	4.4	.8
Wheat Middlings -----	90.0	16.9	53.6	4.1	3.2	1.0
Rye -----	91.3	9.5	69.4	1.2	2.1	1.7
Barley -----	89.2	8.4	65.3	1.6	2.5	1.2
Emmer -----	92.0	10.0	70.3	2.0	3.9	1.1
Oats, whole -----	89.6	10.7	50.3	3.8	3.2	1.2
Oats, ground -----	88.0	10.1	52.5	3.7	3.2	.8
Canada field peas -----	85.0	19.7	49.3	0.4	2.4	1.9
Cow peas -----	85.4	16.8	54.9	1.1	3.2	1.9
Soy beans -----	88.3	29.1	23.3	14.6	4.8	1.9
Kaffir corn -----	90.1	5.2	44.3	1.4	1.6	1.7
Linseed meal OP. -----	90.2	30.2	32.0	6.9	5.5	1.1
Linseed meal NP. -----	91.0	31.5	35.7	2.4	5.5	1.1
Cottonseed meal -----	93.0	37.6	21.4	9.6	6.6	1.5
Dried brewer's grains -----	91.3	20.0	32.2	6.0	3.7	.6
Malt sprouts -----	90.5	20.3	46.0	1.4	6.1	.6
Dried distiller grains -----	92.4	22.8	39.7	11.6	2.0	.6
Dried beet pulp -----	91.6	4.1	64.9	-----	4.5	.6
Alfalfa -----	90.9	9.8	40.8	0.9	11.2	-----
Roughage						
Alfalfa, West United States -----	93.2	11.1	39.1	0.6	10.6	-----
Red clover -----	84.7	7.1	37.8	1.8	6.2	-----
Cow pea hay -----	89.5	5.8	39.3	1.3	14.2	-----
Soy bean hay -----	88.2	10.6	40.9	1.2	7.0	-----
Oat and pea hay -----	89.5	7.6	41.5	1.5	7.1	-----
Oat and vetch hay -----	85.0	8.3	35.8	1.3	7.4	-----
Oat hay -----	86.0	4.7	36.7	1.7	5.7	-----
Timothy hay -----	86.8	2.8	42.4	1.3	4.4	-----
Millet hay -----	86.0	5.2	33.6	0.8	7.9	-----
Corn fodder -----	57.8	2.5	34.6	1.2	2.7	-----
Corn stover -----	59.5	1.4	31.2	0.7	3.4	-----
Sorghum hay wheat straw -----	90.4	0.8	35.2	0.4	4.2	-----
Oat straw -----	90.8	1.3	39.5	0.8	5.1	-----
Rye straw -----	92.9	0.7	39.6	0.4	3.2	-----
Succulent Feeds						
Green corn -----	20.7	1.0	11.9	0.4	1.2	-----
Green sweet corn -----	20.9	1.2	12.6	0.4	1.3	-----
Sorghum -----	20.6	0.6	11.6	0.3	1.1	-----
Canada field peas -----	15.3	1.8	6.9	0.3	1.3	-----
Cow peas -----	16.4	1.8	8.7	0.2	1.7	-----
Soy beans -----	24.9	3.1	11.0	0.5	2.6	-----
Alfalfa -----	28.2	3.6	12.1	0.4	2.7	-----
Clover -----	29.2	2.9	14.9	0.7	2.1	-----
Oats, in milk -----	37.8	2.5	18.2	1.0	2.5	-----
Oats and peas -----	20.3	1.8	10.2	0.4	1.6	-----
Oats and vetch -----	20.0	2.3	10.0	0.2	1.8	-----
Millet, barnyard -----	25.0	1.6	14.4	0.3	1.9	-----
Wet brewers' grain -----	23.0	4.9	7.6	1.7	1.0	-----
Wet beet pulp -----	10.2	0.5	7.7	-----	0.6	-----
Corn silage -----	26.4	1.4	14.2	0.7	2.1	-----
Red clover silage -----	23.0	1.5	9.2	0.5	2.6	-----
Corn cannery refuse, husk silage -----	16.2	0.4	10.1	0.4	0.6	-----
Corn cannery refuse, cob silage -----	25.9	0.3	13.7	0.9	0.5	-----
Pea cannery refuse silage -----	23.2	2.1	13.1	0.8	1.3	-----
Corn and soy bean silage -----	24.0	1.6	13.2	0.7	2.4	-----
Mangels -----	9.1	1.0	5.5	0.2	1.1	-----
Sugar beets -----	13.5	1.3	9.8	0.1	0.9	-----
Turnips -----	9.9	0.9	6.4	0.1	0.9	-----
Rutabaga -----	11.4	1.0	8.1	0.2	1.2	-----
Cabbage -----	10.0	2.3	5.9	0.1	0.9	-----
Potatoes -----	20.9	1.1	15.7	0.1	0.9	-----

*The digestible nutrients in feed are the digestible portions of each nutrient in that feed.

Gluten Feed: This corn by-product is fed by a great many dairymen. In most seasons it is a fairly economical source of protein, but varies greatly in price. Being a corn by-product, it should not be the only concentrated feed used to balance the corn ration, as it does not add sufficient variety.

Oats: There is no better grain than oats for cows producing milk, cows about to freshen, or young, growing cattle. It will be noted from the preceding table that they are rich in the desired nutrients. However, often oats are rather high in price compared to many other feeds and consequently can be fed only in limited amounts. There are oat by-products on the market, but they are of little value for milk production.

Barley: This is a common feed where corn is not successfully grown, as in the west and north and in northern Europe. Rolled barley, rather than ground, is usually fed. Barley by-products are commonly used for dairy cows. The wet barley products must be fed fresh and therefore are available only near breweries. Dried malt sprouts and dried brewer's grains are shipped long distances and fed with profit. The dried brewer's grain ranks with bran and oil meal in palatability, has a good effect upon the system and is fairly high in digestible protein. Dried brewer's grains are oftentimes sold under many different brand names. Dried Distiller's grains are a very valuable feed for dairy cows, being light and bulky and containing a high percentage of valuable nutrients.

Wheat: This is an excellent feed but, of course, is usually too high in price to be fed except when damaged.

Bran: Very wide use is given to bran for dairy cows, as well as young, growing animals. It is fairly rich in valuable constituents, palatable, bulky, and has a laxative, cooling effect on the digestive tract. However, bran is rather an expensive feed. In 100 pounds of it there is less than 12 pounds of digestible protein, while there are more than 20 pounds of digestible protein in gluten feed and dried brewer's grains, over 30 pounds in oil meal, and over 37 pounds in cottonseed meal. Except in the case of cows just before and after calving, cows on official test and young, growing animals, other feeds return greater profits than bran. Wheat middlings and shorts are comparatively high in protein, yet are not as palatable as many feeds for the dairy cow and should be fed in very limited amounts, if at all.

Cottonseed Meal: This is one of the richest and heaviest of feeds. If of good quality, and fed in limited amounts with other feeds, it is especially valuable for dairy cows, being one of the cheapest sources of protein. When wet, mouldy, or if it has heated, it should not be fed. Cottonseed meal is very constipating in its effect upon the digestive tract and, as it contains a poisonous substance, it should not be fed to swine, young calves or cows soon to freshen. When fed to cows producing milk some cooling laxative feed, such as silage or oil meal, should be fed also and it is best not to feed more than 2 to 2 1-2 pounds per cow per day.

Linseed Oil Meal: One of the best dairy feeds, is linseed oil meal, as it is high in desirable nutrients, and palatable, and has a

laxative, cooling effect upon the digestive tract. One to two pounds will improve any ration. Old processed, rather than new, should be purchased, as it has a higher feeding value.

Alfalfa Feeds: There are many alfalfa feeds on the market and, while they are palatable, most of them are expensive from the standpoint of nutrients contained.

IOWA HAYS AND THEIR VALUE.

Alfalfa: It is conceded by practically all that alfalfa is the very best hay that can be fed to dairy animals. It is rather rich in valuable nutrients, very palatable, has a good effect upon the system, and, as it can be grown upon any Iowa farm, it is a very economical feed to help balance the corn and silage ration. In 1912 the field on the college farm yielded 7.03 tons of field cured hay per acre.

Clover: This is an excellent hay and is second to alfalfa in all the points brought out above. Care should be taken to cut it at the right stage of maturity for best results.

Oats and Canada Field Pea Hay: This makes an excellent substitute for alfalfa and clover hay where the acreage of these crops is too small to supply the dairy herd. Excellent results have been secured at the college dairy farm from sowing 1 1-2 bushels of oats and 1 1-2 bushels of Canada field peas per acre. These are best sown with a grain drill, sowing the peas first, and deeper, than the oats. To make the best hay it should be cut when just passing from the milk to dough stage.

Timothy: While timothy is grown upon nearly every Iowa farm and has a high value as a feed for horses, it should not have a place in the ration of the dairy cow. It lacks the nutrients which the milk producing cow and young, growing animals must have; in addition, it is not very palatable and has a binding effect on the digestive system instead of the beneficial effect of alfalfa or clover. The composition table previously given shows that a ton of alfalfa hay contains about four times as much digestible protein as timothy, and seven or eight times as much ash or mineral matter. The man who has only timothy hay for his cows had best sell a portion of it and purchase with the proceeds alfalfa or clover hay and next season get started growing one of the other hay crops.

Straw, corn stover, etc., should not be fed in large quantities as the sole roughage, but the cows will oftentimes relish small quantities if fed in addition to their silage and alfalfa or clover hay.

SILAGE AND ITS EFFICIENCY.

No dairy farm is complete in its equipment without at least one silo for winter feeding and one with a smaller diameter for summer feeding. The characteristics of good corn silage make it pre-eminently a feed for dairy cattle. It is palatable, succulent, bulky, beneficial to the digestive tract, and economical. These are all essential characteristics of the ration which is essential to the largest and most economical flow of milk. Most dairy farmers in the corn belt realize that to secure the largest possible profits from a herd of cows they must feed corn silage. In regions where corn cannot be grown successfully for silage, many dairy men have silos in which they cure other crops.



Fig. 5. Holstein cow—Geneseo Belle Polkadot, owned by Iowa State College and holder of the following official records:

	Pounds Milk	Pounds Butter Fat	Average Test
1 day	108.8	4.1	3.76
7 days	733.6	27.508	3.74
30 days	2,773.0	98.0	3.53
365 days	20,816.2	732.94	3.35

Experiments carried on at the different experiment stations show conclusively that silage is far superior to shock corn or hay in milk production. Silage fed cows produced from eleven to eighteen per cent. more milk than cows fed fodder from the same acreage.

The principal reason why a dairy cow increases her milk flow when she is turned out to pasture in the spring is that she is receiving a succulent feed. Thus, to secure a large and persistent flow of milk during the winter months some succulent feed must be secured to take the place of the pasture grass of summer. The two most common succulent feeds for winter are corn, silage and roots. Experimental work has proved that the silage, as compared to roots, yields more heavily per acre, costs much less and gives equal results from similar weights of dry matter. Silage is also very desirable for the herd during the latter part of July and the month of August, when the pastures are usually very short, due to hot weather and lack of rainfall. The value of silage or soiling crops at this season does not lie solely in the temporary increase in milk flow, but also in maintaining it, if a cow once declines in her milk flow it is practically impossible to bring her back to normal for the remainder of her lactation period.

EFFECTS OF SILAGE ON MILK.

Contrary to the opinion formerly held, milk from silage fed cows is not inferior in flavor or odor to milk from cows fed dry feed. The

condensed milk companies which formerly did not favor milk from silage fed cows are now advising their patrons to put up silos. Great care should be taken, however, to prevent the odor of silage from contaminating the freshly drawn milk, which takes up odors very quickly. It is best to feed the silage after milking and just what will be eaten up clean at that feed. The silos should be shut off from the barn proper. The idea still held by some, that corn silage will destroy the teeth and digestive tract of the cow and induce such diseases as tuberculosis, is erroneous.

ROOT CROPS.

Many of the root crops furnish succulence to the dairy cow in very acceptable form, yet for the practical man they are too expensive as compared to corn silage to be fed in large quantities or in the place of silage.

BEET PULP.

Beet pulp is a very good feed and farmers living near a beet sugar factory usually secure the wet pulp for a very reasonable price. Dried beet pulp is an excellent feed and when one cannot have corn silage it proves to be a very valuable substitute. It is best when soaked twelve hours before feeding, allowing from four to seven pounds of dried beet pulp per cow per day when on full feed.

SOILING CROPS.

The pastures upon most Iowa farms do not furnish enough feed for the cattle during the hot, dry months of summer. The problem of supplying the necessary succulent feed most economically is important and may be solved by one, or a combination, of the following methods:

1. Better care and management of pastures.
2. Use of summer silo.
3. Use of soiling crops.

Better care and management of pastures is absolutely necessary to secure the best results from farms. In every neighborhood a practical demonstration may be found that a little care given to a pasture will greatly increase its production of feed. But the pasture crop in itself is not enough for dairy farmers or for many beef cattle growers. To secure the greatest possible returns from their land, they find it to their advantage to keep more cattle than they can properly pasture without the aid of silage or soiling crops. The use of silage or soiling crops upon dairy farms results in a saving of land, fencing, feed and manure, and in greater and more profitable production of milk.

SILAGE OR SOILING CROPS.

Whether corn silage or soiling crops will be more economical and efficient in supplementing the pasture will depend somewhat on specific conditions. The experimental work which has been conducted along this line has not furnished very conclusive evidence in favor of either. Evidently a silo small in diameter filled for summer use is the most satisfactory and economical solution of the

problem on the average Iowa farm. Most of the soiling crops require more labor in getting them to the animals than the average farmer, who practices mixed farming, wishes to spare from the field work in the busy season of the year.

However, the man who has a large herd of dairy cattle and wishes to secure the best possible returns from his acreage will find it to his advantage to grow some soiling crops. There is nothing better than fresh, palatable, nutritious green feed to stimulate milk production. Then, too, by having in each mixture a leguminous plant, soiling crops can be grown that are superior to corn silage in balance of nutrients. Another class of farmers who profit by the use of soiling crops are the renters who cannot persuade their landlords that silos are necessary fixtures upon farms. To these classes must be added the men who have not put up silos yet and who wish to grow crops to feed in addition to their pastures during the coming summer.

SOILING CROP SYSTEM ON COLLEGE DAIRY FARM.

During the past three years soiling crops have been successfully grown and used upon the Iowa State College dairy farm at Ames. Such varieties have been chosen as would furnish a succession of green feed to supplement the limited acreage of blue grass pasture. Under this system the cows have been turned into the pasture nights and forenoons and then put into the barn about 2:30 p. m. and given a liberal allowance of the freshly cut green feed. Under ordinary conditions, the above, or partial, soiling system is more satisfactory than to keep the cows confined all the time and haul all the green feed to them as is done on some of the larger dairy farms. It is also much more satisfactory than to feed the cows the green feed on the ground in the pasture, as is sometimes done, with much soiled and wasted feed as a result.

Increased production of milk from decreased acreage has been the result secured at the college dairy farm from this system of soiling crops. By bringing the cows into the barn at the time of day when the heat and flies are especially troublesome and spraying them to remove flies, it is made possible for them to eat their feed in comfort. Thus they are enabled to keep up a normal flow of milk when they would ordinarily decline seriously. Also, because these palatable green crops are used, less grain needs to be fed the heaviest producers, while ordinary producers may be kept up in production and condition without grain.

In 1911 thirty-seven cows were kept on 19½ acres of pasture and in addition were supplied with the soiling crop from 8 acres. Counting the land devoted to both pasture and soiling crops each cow was kept the entire season on .74 of an acre. The value of the soiling crops may be fully realized when it is remembered that the summer of 1911 was one of scanty rainfall and many farmers in the vicinity of Ames were allowing 2½ to 3 acres of pasture for each cow. In 1912, 45 cows were kept on the 19½ acre pasture and in addition were allowed a trifle over 6 acres of soiling crops—or each cow was kept on about .6 of an acre. In addition to this, in 1912 the cows grazed on a 15 acre meadow for a few weeks,

beginning about the middle of August. It was found in 1912 that the entire cost of pasture and soiling crops for each cow, counting rent of land, labor, seed, etc., was only \$6.62 for the entire pasture season.

LABOR NECESSARY FOR SOILING CROPS.

The objection usually raised to growing soiling crops is the amount of labor necessary to cut and haul the feed to the cows each day. On the college dairy farm this takes two men about one and one-half hours each day. In 1912, with 45 cows, it was found that a team and mower could be used to good advantage in cutting the daily allowance of feed. Considering the value of soiling crops in increasing production and decreasing cost of production of dairy products, it will be found that excellent returns are secured for time spent.

SUCCESION OF SOILING CROPS USED ON THE IOWA STATE COLLEGE DAIRY FARM.

Approximate Time of Cutting	Crops	Approximate Time of Sowing	Rate of Seeding per Acre	Avr'ge Yield of Green Food per Acre
June 10 to June 15	Alfalfa -----	Spring or August	20 lbs. -----	8 tons
June 15 to July 5	Oats and Canada Field Peas -----	April 5 -----	1½ bu. oats -----	5 tons
July 1 to July 10	Oats and Canada	April 20 -----	1½ bu. peas -----	
	Field Peas -----		1½ bu. oats -----	
July 10 to July 15	Alfalfa -----	Spring or August	20 lbs. -----	4 tons
July 10 to July 20	Amber Fodder Cane -----	May 5 -----	70 lbs. -----	20 tons
July 15 to Aug. 15	Fodder Cane and Cow Peas -----	May 15 -----	30 lbs. cane -----	12 tons
Aug. 15 to Sept. 20	Fodder Cane and Cow Peas -----		1 bu. cow peas -----	
Sept. 20 to heavy frost -----	Millet -----	June 10 -----	30 lbs. cane -----	12 tons
		July 10 -----	1 bu. cow peas -----	3 tons
			3 pecks -----	

PREPARING THE COW FOR HER YEAR'S WORK.

The proper time to begin feeding a cow for milk production is six to eight weeks prior to freshening. She should have at least this length of time to rest and prepare for the next lactation period. The feeds given at this time should meet the following requirements: Rest and cool out the digestive tract, supply nourishment for the growth of the foetus or unborn calf, and build up the flesh and strength of the cow herself.

For the cows that are to freshen during the summer or early fall it is a good plan to have a small pasture set aside so that they may have abundance of pasture grass and not be molested by the other cows. In addition to this a few pounds of ground oats and in some cases a small quantity of bran will be sufficient. Cows that are to freshen during the winter should receive from 20 to 25

pounds of corn silage, all the clover or alfalfa hay they desire and a grain mixture of 3 parts ground oats, 2 parts bran and 1 part oil meal. The amount of grain per day is to be governed by the individual animal. Animals thin in flesh may be given a small quantity of corn but should not be crowded, but rather fleshed up gradually. Timothy hay and cottonseed meal are not desirable as they are rather constipating, while laxative feeds are needed at this time. Too large a quantity of corn is likely to have a bad effect upon the system. It is well to reduce the ration slightly just prior to calving as by so doing the danger of milk fever and after-calving troubles is decreased to some extent.

A few days before calving put the cow in a clean, disinfected, well bedded box-stall, if her bowels are not moving freely, a dose of 3-4 to 1 pound of epsom salts or one quart of raw linseed oil will prove very beneficial. A grain ration of 2 parts bran and 1 part oil meal is very good at this time.

For a few days after calving the cow's drinking water should be luke warm. In addition to alfalfa or clover hay and a small quantity of silage, she should be fed bran mash or a small allowance of bran, oil meal and ground oats. If the cow does not pass the after-birth promptly and the man in charge does not understand the anatomy of the reproductive organs, a competent veterinarian should be called; that should be done also when the cow has difficulty in calving.

CARE OF COW FIRST THIRTY DAYS AFTER CALVING.

If the cow has been properly cared for the first three days she may then be placed on dry and more solid food. The manner in which she is fed during the next thirty days determines largely the character of the work she will do during her lactation period. Experienced feeders of beef cattle realize that thirty days are required to get steers on full feed, and likewise the dairy cow needs to be given thirty days. Without doubt parturition weakens the digestive apparatus and heavy feeding soon after calving is liable to be followed by indigestion, bloat or impaction. During the first thirty days after parturition the maternal instinct is at its highest pitch and during this time, if properly cared for, the cow can be brought to her greatest possible milk flow.

To do this, the feeds must be suited to the individual cow's needs. Beginning on the fourth day with five pounds of grain daily, the ration should be increased slowly—say at the rate of 1-2 pound each alternate day. This rate of increase is rapid enough, for the cow will respond as well to a half pound increase as she will to a pound. This increase may continue just as long as the cow continues to increase profitably in her milk flow. When she ceases to respond, then the feed should be lessened in the same gradual manner for a few days and it will, as a rule, be noted that the cow will further increase in milk flow. The feed given on the day she begins to decline in milk determines practically the amount of grain she should receive. Much less than this amount will not compel her best work and any additional feed will be worse than wasted.

The exact amount and quality of the food will be determined by the condition and individuality of the cows. Seldom do two

cows demand to be fed in exactly the same way. Cows inclined toward beefiness require a narrow ration, or one containing a proportionately large amount of protein; cows of the strictly dairy type, inclined to work hard and become thin in flesh, need to be fed more extensively of foods rich in carbohydrates. Cows of large capacity and the ability to produce great volumes of milk require more than cows with less capacity and ability.

AMOUNT TO FEED.

The amount of feed given the cow is of great importance. The average dairy cow requires about 50 per cent of a normal ration for maintenance. Consequently, if this cow is fed but one-half the normal ration, she receives simply enough to maintain her body and the milk she gives will be produced at the expense of her body tissues. Under such conditions the flow of milk would no doubt keep up for a time, but the animal would not be able to continue the work and her strength for a very long period. This is one of the chief reasons why cows on many farms drop off rapidly in milk flow after the first two or three months of their lactation periods. It is poor economy to under-feed the dairy cow because her maintenance requirements for the year will remain the same and her milk production will be certain to suffer.

There are cows that are over-fed, thus receiving food in addition to the requirements for maintenance and milk production, and this extra food is used for fat formation. This happens where all the cows are fed alike, irrespective of lactation period and production. This is also poor economy, because when many cows start to "flesh up" they continue to do so at the expense of milk production.

The best ration will depend upon the condition, individuality and record of the cow, but it is a common practice to allow 1 pound of grain for each 2 1-2 to 4 pounds of milk produced, depending upon the richness of the milk, or 7 pounds of grain for each pound of butter fat. In addition to this grain ration, the average cow should receive 1 to 1 1-2 pounds of clover or alfalfa hay and 2 1-2 to 3 pounds of corn silage for each 100 pounds live weight.

Because the prices for the different feeds vary so much from year to year and from one locality to another, it is impossible to designate just what grain mixtures are most efficient and economical. However, the following mixtures meet the requirements of a good grain mixture to be fed in conjunction with corn silage and alfalfa hay, provided the feeds can be bought at a price which will make the ration comparatively economical:

Sample Mixture A.

300 pounds corn and cob meal
200 pounds ground oats
100 pounds cottonseed meal
100 pounds oil meal

Sample Mixture B.

400 pounds cracked corn
100 pounds oil meal
200 pounds gluten feed
100 pounds dried brewer's grains

Sample Mixture C.

200 pounds corn and cob meal
100 pounds ground oats
100 pounds gluten feed
100 pounds cottonseed meal

Sample Mixture D.

400 pounds corn and cob meal
100 pounds oil meal
100 pounds bran
200 pounds cottonseed meal

FEEDING GRAIN IN SUMMER.

Dairy farmers are divided in their opinion as to whether or not it pays to feed grain when the cows are on pasture. The practice of many successful dairymen, and the one in vogue at the college dairy farm, is to give the animals no grain the first month they are on grass. Thus they secure a rest. Later a small quantity of such feeds as cracked corn, cottonseed meal, ground oats, etc., should be given the heavier producers in addition to the silage or soiling crops to keep the cows up in flesh and production.

ENCOURAGING PERSISTENCY OF LARGE MILK FLOW.

The persistent cow, or the one that milks well for the entire lactation period, is the profitable cow. In order to induce persistency the following points must be observed in addition to weeding out the non-persistent animals:

1. Proper feeding.
2. Breeding to calve in fall of year.
3. Proper milking and manipulation of udder.
4. Regularity.
5. Kindness.
6. Grooming.
7. Watering.
8. Salting.
9. Keeping flies from cows.

Proper feeding must extend throughout the year and the ration changed to meet the changing needs of the cow. If the cow begins to fatten, lessen the carbohydrates and increase the protein in the ration. If she begins to get poor, increase the carbohydrates. Regulate the amount of feed by the amount of milk and butter fat produced. Cows producing milk rich in butter fat need more grain in proportion than do cows producing a low testing milk.

Breeding to Calve in Fall: Cows bred to calve in the fall will yield from 15 to 25 per cent more milk in the year than if they freshened in the spring, because in the former case when they go out on pasture in the spring they will increase slightly in milk flow, while if they freshen in the spring they are worried by the hot weather and flies, and oftentimes by a scarcity of feed, and soon start to decline in flow. Another factor of importance in this connection is the fact that irrespective of time of freshening, cows will give a slightly higher per cent of fat during the winter months than during the hot summer months. There are many other reasons why it is better to have the majority of the cows calve in the fall; for instance, the higher price paid for butter fat during the winter months, the time available for looking after the herd during the winter months, and the fact that calves born in the fall have a better chance for growth during the first year.

Milking and Manipulating the Udder: The cow should be milked by the same man at the same time each day, and always milked



Fig. 6. Spraying the cows and feeding them soiling crops increases their comfort and greatly increases production and profit.

dry, for production is influenced as greatly by proper milking as by proper breeding. After the milk has apparently all been drawn, the udder should be rubbed and massaged, for this stimulates the milk producing glands. Regularly manipulating the udder will add to the persistency with which the cow milks and to the richness of the milk, because the last drawn milk is richest in butter fat.

Regularity: Regularity has been mentioned in several connections, and here it is sufficient to say that no one will be a very successful dairy farmer who is not regular with every detail of the work.

Kindness: No farm animal responds so quickly to kindness as the dairy cow. Harsh words, noise, and milk stools improperly used always decrease the milk flow greatly.

Grooming: Cows groomed will yield more than enough additional milk and butter fat to pay for the ten or fifteen minutes of extra labor daily, not to mention the difference in the cleanliness of the milk and in their appearance. Grooming stimulates the circulation of the blood and in this manner aids in food digestion and milk secretion, as well as in general health.

Watering: In winter cows should have drinking water that is warmed and at all times pure, clean and fresh. The importance of this is realized when it is remembered that about 87 per cent of normal milk is water. A short time ago it was found that one of the college Holstein cows which was producing 100 pounds of milk per day was drinking from 200 to 250 pounds of luke warm water per day. It is readily seen that if that cow had been forced to drink ice water out of a tank, as many cows in this state are forced to do, the milk flow would have been materially decreased.

Salting: Salt is quite essential to best results and should always be available to the cow. Keep salt in front of the cow rather than mix it with her grain ration.

Keeping the Flies from Cows: By preventing flies from tormenting the cows much greater flow of milk is secured during the summer months and the remainder of the lactation period. The following home-made mixture has given good results at the college dairy farm. It is better than several other mixtures tried, and quite as efficient as the prepared sprays costing a dollar per gallon. It is made as follows:

1½ quarts of any standard coal tar dip.

1½ quarts of fish oil.

1 pint of oil of tar.

1 quart of coal oil.

½ pint of oil of pennyroyal.

Mix in ten gallons of luke warm soft water in which a bar of laundry soap has been dissolved.

Spray twice a day, in the morning after milking and in the afternoon when cows are brought in for silage or green feed. When a half barrel cart with spray nozzle attachment is used two men can spray a herd of forty cows in ten minutes. This mixture is not perfect and does not keep all the flies away and, furthermore, it leaves the coat rather harsh and causes dust to adhere; however, it is very beneficial and practical.

INFLUENCING BUTTER FAT PRODUCTION.

There is only one way that butter fat can be increased with certainty and in a large way. That is by obtaining a large and persistent flow of milk. However, it is evident that each of the following factors may have a slight influence upon the per cent of fat in the milk: breed, individuality, age, period of lactation, condition, excitement, frequency of milking, season of year, temperature, feed, whether first or last drawn milk and grooming.

Breed and Individuality: The influence of breed and individuality need not be discussed, as the variations due to these factors are known to all.

Age: Young heifers will nearly always produce milk testing a higher per cent of fat during their first lactation period than during succeeding lactation periods, other conditions being the same. In her two year old form the heifer will usually produce about 70 per cent as much butter fat in a year as she will as a mature animal.

Period of Lactation: The fact that cows produce a milk richer in butter fat toward the close of their lactation periods is well known. However, cows that are in high condition at calving time will produce for a time milk testing much higher than their average for the lactation period.

Condition: The physical condition of the cow may affect the test slightly. Cows that are ill will usually test a trifle higher than their average.

Excitement: Cows that are excited, either due to some disturbance or to the fact that they are in heat, will usually test slightly higher than the average, but some individuals test lower.

Frequency of Milking: It is a common practice to milk cows on official or yearly record work three and sometimes four times per day. It is noticed that the great majority of the cows will give the highest per cent of fat following the shortest interval between milkings. Thus a slightly higher per cent of fat as well as a larger quantity of milk may be secured by these frequent milkings, but with the average cow under farm conditions not enough more to pay for the extra labor.

Seasons of Year and Temperature: It has been found that irrespective of the time of calving, cows will give a slightly higher test during the winter months than during the hot summer months and, furthermore, that on very hot days the per cent of fat will usually show a marked decrease.

Feed: Many have contended that it is possible to increase the percentage of butter fat in milk by feeding certain feeds high in fat content. However, experiments have proved that it is impossible to do so to any great extent or for a very long time. Certain oils added to the grain ration have resulted in a temporary increase, but the per cent of fat soon drops back to normal, even though the feeding is continued.

Whether First or Last Drawn Milk: The last milk is much richer than the fore milk. A trial showed the fore milk from a Jersey heifer to test 2 per cent fat while the strippings tested

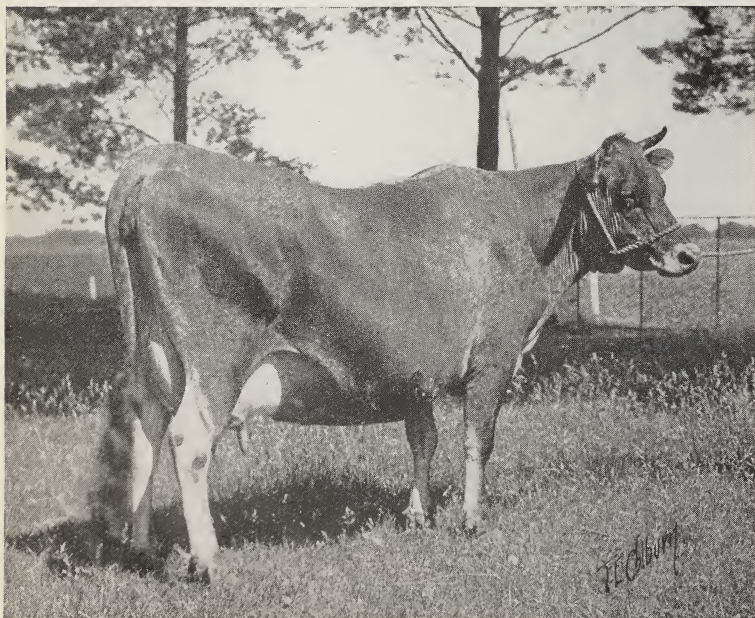


Fig. 7. Figgis 28th of Hood Farm, owned by Iowa State College. In one year this Jersey cow produced 12,131 pounds of milk and 675.2 pounds of butter fat.

over 15 per cent. This shows the importance of proper milking and manipulating the udder.

Grooming: The stimulation of the circulation by proper grooming has been found to cause a slight increase in the per cent of fat in the milk.

REARING THE CALVES.

To successfully rear calves a great deal of care and attention must be given them during the first six months. But this care is well warranted and is highly paid for by the greater number of calves saved from the ravages of scours and other diseases and the better quality of mature animals that they make later in life.

To guard against navel infection, which so frequently causes the death of calves, the following method has proved to be very efficient:

1. Draw liquid from navel cord as soon as calf is born.
2. Apply tincture of iodine liberally to cord, both internally and externally.
3. Dust compound alum powder on the cord every few hours for one day.

The question of whether the young calf should be left with the cow for a few days or whether it should be taken away immediately is one upon which practical dairymen are not agreed. In most cases it is the practice at the college dairy farm to leave the calf and cow together for two or three days so that the calf may secure the first milk, or colostrum, at the normal temperature, which is quite essential in starting the digestive system properly. Then, too, the calf assists in relieving the inflammation in the cow's udder at this time.

During the first three weeks of the calf's life after being taken from the dam, it should be fed from 2 to 3 1-2 pounds of whole milk three times a day. Care should be taken to feed this milk immediately after being drawn, before it becomes cool. When the calf is three weeks of age it may be fed twice a day and skim milk can gradually and slowly be substituted for a like amount of whole milk. Three more weeks should be used in getting the calf onto a whole ration of skim milk. When it reaches the age of six weeks it should be receiving from 12 to 16 pounds of warm milk per day. Great care should be taken not to over-feed the calf with milk, as more calves are injured by over-feeding than by under-feeding. At the college farm best results are secured by 16 pounds per day if fed when on full feed. It is usually advisable to continue the skim milk feeding until the calf is about eight months of age.

GRAIN RATIONS FOR CALVES.

A grain ration of equal parts corn, oats and bran, with a small quantity of oil meal, should be provided for the calf. Even when but a few weeks old it will begin to eat the grain, and nibble at the hay. It is best to feed cracked corn at first and then later substitute shelled corn. Whole oats are better than ground oats for the young calf. Clover hay, or mixed clover and alfalfa, is superior



Fig. 8. Ayrshire and Jersey heifers, five months of age, at Iowa State College.

to alfalfa alone for the young calf, as alfalfa alone is too rich for the kidneys and digestive tract.

Calves dropped in the fall and early winter will do well on pasture the first summer if provided with some grain and shade, while calves dropped in the spring or early summer are much better off when properly cared for in the barn during the first summer.

SCOURS IN CALVES.

Thousands of calves are lost each year, due to what is known as scours. On every farm measures should be taken to guard against this disease, which results from a deranged digestive system. The calves should have warm, clean, light and well ventilated pens. The milk must be fed in regular amounts, at regular times, at a temperature of about 80 degrees F., from scrupulously clean pails. The foam which accumulates on the milk while it is being separated should never be fed. The time to feed the grain ration is immediately after the milk is fed, so that the calves will not suck each other's ears and thus take air into the stomach, which causes bloat and produces scours. It is well to have stanchions on one side of the pen so that the calves may be confined for a short time after being fed milk.

Each day during the winter, when the weather is favorable, the calves need to be turned out into a sheltered yard for exercise, which is necessary for their proper growth and health. It is also very important that the calves, from a very early age, be given all the pure, fresh water they care to drink each day. The pens should be disinfected frequently. Quick lime is excellent to sprinkle on the floor each time it is cleaned and a frequent spraying with some standard coal tar dip solution will prove beneficial.

SUBSTITUTES FOR MILK.

There are several calf meals on the market which seem to give very good results, especially when fed in addition to a small quantity of milk. There are many home made mixtures which are fairly efficient and the following statement concerning "hay-tea" from Henry's Feeds and Feeding may be of interest:

"Stewart gives the following satisfactory experience with a hay-tea ration for calves: 'If the hay is cut early when it has most soluble matter, and is good quality, the tea will grow good calves, but this extract frequently has too small a proportion of albuminous and fatty matter. Yet, if the hay-tea is boiled down so as not to contain too much water for the dry substance, calves will usually thrive upon it. We tried an experiment by feeding 2 gallons of hay-tea, in which one-fourth of a pound of flax seed and one-fourth of a pound of wheat middlings had been boiled, to each five calves thirty days old. This experiment was continued sixty days, with a gradual increase, during the last thirty days, of the middlings 1 lb. per day. These calves did well, gaining on an average over 2 lbs. per head per day.'"

FEED AND CARE REQUIRED BY DAIRY HEIFERS.

In rearing a dairy heifer from birth to freshening, the chief purpose is to grow a large, strong framework and body and that should ever be uppermost in the dairyman's mind. Every care possible should be given to stimulate the growth of bone and muscle. If a fall calf, of course, it is kept in a warm barn and well fed with skim milk, clover or alfalfa, corn, oats, bran and oil meal until late spring, when it may be turned on good pasture. But the feeding of the same grain should be continued all through the summer in a more limited way, increasing the oats and corn at the expense of the bran and oil meal. In the heat of the summer the young animal needs shelter from the heat and flies in the same manner as the cows. When cold weather first comes, give the heifer the run of a shed, always providing her with an abundance of clover or alfalfa hay, corn stover, and a limited amount of silage to keep her growing. Feed largely of these coarse feeds to develop a large, well distended digestive apparatus. In the past it has been advocated that if the heifer becomes fat she will be worthless as a dairy cow. However, if fed proper foods, such as we have mentioned, and if a good growth and large, well distended barrel have been developed, many fat heifers, when they come into milk, make excellent dairy cows. But to feed the heifer fattening foods only is apt to ruin her for the dairy when she matures.

RATIONS FOR DAIRY HEIFER.

The following are excellent rations for yearling dairy heifers during the winter months:

1. Silage	20 lbs.	2. Clover or alfalfa hay....	15 lbs
Clover or alfalfa hay....	8 "	Grain	1 "
Grain	2 "	Roots	20 "
3. Clover or alfalfa hay....	15 lbs		
Grain	3 "		

Give the heifers good, comfortable quarters, preferably a shed open to the south, clover hay, corn silage or roots, a little corn, bran and ground oats, with some corn fodder and straw once in a while for a change. Silage or roots will take the place of succulent pasture grass and will tend to keep them in good health.

WHEN TO BREED.

The proper time to breed the heifer will depend upon the breed as well as the growth and development of the individual. Early maturing animals of the Jersey and Guernsey breed should ordinarily be bred to freshen at 25 or 26 months of age, while Holsteins, Ayrshires and Brown Swiss heifers should freshen at about 28 months of age. Heifers that are large and heavy fleshed should be bred younger than smaller heifers of the same breed. It costs from \$50.00 to \$60.00 to grow a dairy heifer up to producing age.

FEED AND CARE OF THE DAIRY BULL.

It is important that the herd bull be kept by himself or with other bulls rather than allowed to run with the herd of cows. It is essential that the dairy bull receive exercise. This may be provided by having a pasture or paddock opening from his shed or stall so that he may go in and out at will, or by turning him out into a special pasture each day. Many dairymen keep the bull exercised by placing him in a tread mill each day, the power being utilized in some cases to run cream separators, washing machines, grind stones, etc. The dairy bull, being a very nervous animal, should never be abused or teased, that may make him mean.

Dairy farmers are practically unanimous in the opinion that a too liberal ration of silage is not good for the herd bull. When so fed the animal is usually rather heavy middled, sluggish and slow in breeding. The large amount of silage distends the middle unduly and does not supply the balance of nutrients necessary to keep the animal vigorous and active in service. In addition to a small quantity of corn silage, alfalfa or clover hay should be fed and a grain ration of corn, oats, bran and a little oil meal.

HERD RECORDS.

"Know your cows" is a stepping stone to success in the dairy business. The only accurate method of determining the relative merits of the cows in the herd and thus make it possible to weed out the cows that do not return a profit, is to make use of the milk scale, the Babcock fat test and the feed record throughout the whole lactation period. The following records should be kept and will prove of great value to the dairyman: Production of milk, production of butter fat, feed records and breeding records.

The production records may be kept by all and require but very little time and effort. Blank milk sheets may be secured from the publishers of any dairy paper and it requires about a minute per day to weigh and record the weight of milk at each milking. To determine the production of butter fat, a careful composite sample

Days After Calving

Age

Date Photo Taken

Feb. 12, 1912 5 yrs./mo. 29 do 114



State College, Ames, Iowa

Holstein

Herd No 45

Class

Lorr

Address Wellington Ohio

er A. Horr

Address Wellington Ohio

er A. Horr

Address Wellington Ohio

ngton Ohio

Date of Purchase Dec. 3, 1907

Date Bred

TO SIR

ADDRESS

Date Sold

Price

Kind of Stock Kept

1	Jan. 12, '08	Colantha 4	North Buena Vesta Iowa	June 1909	\$ 75 ⁰⁰	Pure Bred Grades
2	Aug. 18, '09	Colantha 4	Hillsboro Iowa	Mar. 1911	\$ 2.00 ⁰⁰	Grades
3	Jan. 17, '11	Colantha 4ny	Nevada Iowa	June 1912	\$ 150 ⁰⁰	Pure Bred Grades
4	June 12, '12	Colantha 4				
5	July 23, '13	Sir Jessie Fob				
6						
7						
8						
9						
10						
11						

OFFICIAL RECORDS

	Lactation Period		M.	Age at Start			Pounds Milk	Pounds Fat	Per Cent Fat	Pounds Butter
	From	To		Years	Months	Days				
1	Nov. 27, '08	Nov. 26, '09		4	10	7	405.80	15.504	3.82	
2	May 30, '10	May 30, '11		4	10	7	16,994.90	552.770	3.25	
3	Oct. 16, '11	Oct. 16, '12								
4										
5										
6										
7										
8										
9										
10										
11										

Feb. 19, 1912 5 yrs. June 29, 1914



DAIRY FARM DEPT., Iowa State College, Ames, Iowa

Name Lucy Duchess DeKol Breed Holstein Herd No. 45
 Registry No. 96348 Advanced Registry No. 16079 Class
 Dropped Dec. 20, 1906 Bred by Esther A. Horr Address Wellington Ohio
 Sire Count DeKol Clothilde Bunker No. 30609 Bred by Esther A. Horr Address Wellington Ohio
 Dam Lucy Duchess Lyons No. 78965 Bred by Esther A. Horr Address Wellington Ohio
 Bought of Esther A. Horr Address Wellington Ohio Date of Purchase Dec. 3, 1907
 Final Disposition

PRODUCE RECORD

	Date Bred	TO SIRE	No.	Due to Calve	Date Calved	Weight Cal	Sex	Herd No.	NAME OF CALF	Registry No.	PURCHASER	ADDRESS	Date Sold	Price	Kind of Stock kept
1	Jan. 12, '08	Colantha 4 th s Lad	26940	Oct. 21, '08	Oct. 23, '08	97	M	83	Prince DeKol of Ames		Sweeney Bros.	North Buena Vista Iowa	June 1909	\$ 75 ⁰⁰	Pure Bred Grades
2	Aug. 18, '09	Colantha 4 th s Lad	26940	May 27, '10	May 22, '10	100	M	113	Sir Colantha DeKol Lad		W. S. Whitaker	Hill'sboro Iowa	Mar. 1911	\$ 200 ⁰⁰	Pure Bred Grades
3	Jan. 17, '11	Colantha 4 th s Lad	26940	Oct. 24, '11	Oct. 27, '11	102	M	159	Duke Colantha DeKol		Oak Park Academy	Nevada Iowa	June 1912	\$ 150 ⁰⁰	Pure Bred Grades
4	June 12, '12	Colantha 4 th s Lad	26940	Mar. 21, '13	Mar. 23, '13	10	M	211							
5	July 23, '13	Sir Jessie Forbes Piebe Bunk	41215												
6															
7															
8															
9															
10															
11															

MILK AND FAT RECORDS

YEARLY MILK AND COMPOSITE FAT RECORDS										OFFICIAL RECORDS									
Lactation Period		Length Period		Age at Start		Pounds Milk	Pounds Fat	Per Cent Fat	Net Income over Cost of Feed	Test Period		Length of Test		Age at Start		Pounds Milk	Pounds Fat	Per Cent Fat	Pounds Butter
From	To	Months	Days	Years	Months	Days				From	To	Months	Days	Years	Months	Days			
1	Nov. 27, '08	Nov. 26, '09	365	1	11	7	10,257.70	316.03	3.10	\$ 49.85	Oct. 16, '11	Oct. 22, '11	7	4	10	7	405.80	15.504	3.82
2	May 30, '10	May 30, '11	365	3	5	11	13,519.40	440.07	3.25	\$ 68.14	Oct. 16, '11	Oct. 16, '12	365	4	10	7	16,994.90	552.770	3.25
3	Oct. 16, '11	Oct. 16, '12	365	4	10	7	16,979.00	543.69	3.20	\$ 124.79									
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			

Fig. 10.—A complete calf and milk and fat record devised at Iowa State College.

Sire Count De Kol Clothilde Bawn

8 ARO Daughters
1 Proven Son

30609

Clothilde Fay De Kol 22.932
Countess Pietertje Rauwerd 18.442
Lucy Duchess De Kol 19.380
Ophelia Queen Lill De Kol 21.520
Serena Countess De Kol 21.048

Pietertje Hengerveld's Count De Kol

23224

98 A.R.O. Daughters
46 Proven Sons

Beauty Rauwerd De Kol 30.538
Blanche De Kol Hengerveld 33.198
Blanche Lyons De Kol 33.312
Frenesta Hengerveld De Kol 32.196
Ida Lyons 2^d 23.122

Aggie Clothilde Bawn

39304

3 ARO Daughters
1 Proven Son

Aggie Clothilde Bawn 5th 19.138
Aggie Clothilde Bawn 4th 19.168
Aggie Clothilde Bawn 2^d 21.186

Lucy Nudine 2^d Prince

26981

16 ARO. Daughters

Blanche of Shadeland 3rd Nudine 25.136
Clementine Lass 3^d 29.123
Cordia Nudine 31.152
Dell Rauwerd 2^d Nudine 23.048
Dell Rauwerd 3^d 22.980
Nudine Lyons De Kol 30.717

Lady Duchess Lyons 2^d

50463

Dam Lucy Duchess Lyons

78965

De Kol 2^d Butter Boy 21566

12 ARO. Daughters 20 Proven Sons

Helena De Kol's De Kol 21.195
Nicola De Kol 22.150
Plum De Kol 20.240

Pietertje Hengerveld 24137

2 ARO Daughters 3 Proven Sons

Clothilde Netherland Count

18003

1 ARO. Daughter
2 Proven Sons

Aggie Bawn 2^d 33754Bellewoods 2^d Hero 25240Lucy Nudine 2^d 27463Lucy Nudine 2^d Monk 23626Lady Duchess Lyons 43418Sir Abbekerk 19056De Kol 2^d 734Milla's Pretaitje Netherland
7825Netherland Hengerveld

13106

Count Clothilde 9915Clothilde 2^d Netherland
11855Petunia Bawn 9486Aggie Bawn 16631Pauline Paul's Grandson's Clothilde
19645Bellewood 2^d 34780Copia's Empire No 2
3914Lucy Nudine 8723Lady of Lyons' Monk
20793Lucy Nudine 2^d 27463Lady of Lyons 6th Monk
21329Duchess Lyons 2^d 38217

	Sir Abbekerk 19056
Butter Boy 21366	
rs 20 Proven Sons	
De Kol 21.195	De Kol 2 ^d 734
22.150	
20.240	Milla's Pieteitje Netherland 7825
Hengerveld 24137	
sters 3 Proven Sons	Netherland Hengerveld 13106
	Count Clothilde 9915
Netherland Count 18003	
	Clothilde 2 ^{d's} Netherland 11855
	Petunia Bawn 9486
Bawn 2 ^d 33754	
	Aggie Bawn 16631
	Pauline Paul's Grandson's Clothilde 19645
2 ^{d's} Hero 25240	
	Bellewood 2 ^d 34780
	Copia's Empire N ^o 2 3914
ine 2 ^d 27463	
	Lucy Nudine 8723
	Lady of Lyons' Monk 20793
ine 2 ^{d's} Monk 23626	
	Lucy Nudine 2 ^d 27463
	Lady of Lyons 6 ^{th's} Monk 21329
hess Lyons 43418	
	Duchess Lyons 2 ^d 38217

profit, good shelter is essential. Food supplied the dairy cow is for the purpose of milk production. The greater amount of food converted into milk, the greater the dairyman's profit. If the cow is compelled to withstand the cold she must necessarily convert a portion of her food into heat with which to warm her body, hence a low milk flow and stunted profits for her owner. All first class dairymen realize this point and consequently all good dairy farms are well provided with good barns, for the cows in milk, at least.

ARRANGEMENT OF BUILDINGS.

In arranging all buildings on the dairy farm the following points are deserving of careful consideration:

- | | |
|-----------------|--------------------------|
| a. Location. | e. Ventilation. |
| b. Convenience. | f. Sanitary conditions. |
| c. Light. | g. Confinement of odors. |
| d. Heat. | h. Appearance. |

From the standpoint of convenience, it would be advisable to have all buildings located close together, but because of the danger of fire on any farm without adequate fire protection this is not desirable. Neither is it advisable to build extremely large barns. On dairy farms where from five hundred to a thousand cows are kept in milk, it has invariably been found more satisfactory to stable only about fifty or sixty cows in one small stable and build a sufficient number of barns to shelter the entire herd.

LOCATION.

Dairy barns should be built on a spot that is high, well drained, and sheltered from the cold northwest winds of winter. At best the lots and paddocks surrounding barns get very muddy and foul in spring time, but when the barn sets on a high, well drained spot the lots soon become dry after the frost leaves the ground.

TYPES OF BARNs.

The following types of barns are used on dairy farms: Basement, round, one-story, and two-story barns, and the covered barn yard or double stabling system. Basement barns are difficult to light and ventilate and should seldom, if ever, be used for housing dairy cows. Too much care in lighting and ventilating the dairy barn cannot be taken. These factors need more attention for dairy animals than for any other class of animals because the cows are confined most of the time for a large portion of the year. If housed in a damp, ill-lighted and ill-ventilated barn, the dairy cow is very likely to become diseased.

Round barns are fairly economical so far as building material is concerned. However, they are nearly always dark and the usual barn odors in them are not confined. Therefore, they are generally not desirable for dairy cattle.

One story barns may easily be made practically ideal, from the standpoint of light and ventilation, but are rather expensive from the standpoint of storage. The one story barn with a monitor roof, while excellent in summer and in warm climates, is cold, hard to ventilate and impractical on the Iowa farm.

Two story barns, if tightly ceiled and provided with proper window space and ventilation, are very practical on the Iowa farm where the storage room is needed.

The covered barnyard or double stabling system decreases the amount of labor required. It must have great quantities of bedding and, if adopted, the cows must be in small lots and dehorned.

CONVENIENCE.

At best a great deal of labor is involved where many cows are milked, but if care and judgment be exercised in locating and building much can be gained by way of convenience in eliminating the work.

It should be the rule in building for cows to face them outward. Impractical dairymen nearly always make the mistake of facing the cows toward each other, and in defense of their faddish idea state that the cows look better and that feeding operations are lessened. But this is a mistake. The experienced dairyman will say that the cows look better facing outward because he first looks at the milking end of the animal.

In barns where cows face inward the herd must be divided whenever driven into the barn, half of them entering a door on one side and the remainder on the other side. Even though the alleyways back of the cows are quite wide, the walls of the barn become splashed and besmeared with manure and the tidy dairyman who prides himself on cleanliness must spend hours keeping these walls scrubbed. Two alleyways become dirty each day and must be scrubbed and it is a great task to clean the manure from two sides of the barn and carry bedding all around the barn to be placed in the stalls. The task of conveying the milk to the milk room is doubled, also, because there can be no one convenient central point to weigh the milk.

When the cows face outward all enter one large door and seek their stalls; a litter carrier running between the rows of stalls will convey all manure directly from the barn. It is impossible for cows to splash walls with manure. There is only one alleyway to be scrubbed and all waste may be quickly swept up. The personal experience gained by the writer on dairy farms where each type of barn was in use convinces him that to keep the barn in a clean, sanitary condition requires twice as much work when the cows face in than when they face out.

The best location for the feed room is at the head of one feeding alleyway with a silo adjoining or at the other end of the same alleyway, and a hay chute at the end of the other alleyway. Then with the feed or silage wagon the feeder can quickly and easily feed around the cows, finishing at the starting point.

For convenience a track on which a litter carrier will run should pass by all stalls so they can be quickly and easily cleaned.

FEEDING METHODS.

In view of the fact that each cow should be fed individually and all grain weighed to her, the task of feeding is a large one and one of three ways may be used:

1. A row of covered boxes large enough to hold a week's feed may be built along the wall in front of the cows and the feed weighed up once a week; then the feeder can pass along and give each cow her feed with a small scoop.

2. A feeding wagon may be divided into apartments, each containing a different food, and the wagon fitted up with a spring balance scale. Thus the ration can be weighed and mixed as fed.

3. In the feed room each cow may have a box just large enough for one day's ration. Each day the feed can be weighed and placed therein. The rack containing these boxes should be mounted on rollers so that they may be rolled along in front of the cows. This method facilitates individual feeding and is quite convenient.

Watering cows in winter entails a great deal of labor if cows are to be watered twice daily, as they should be. Many devices have been patented and placed on the market for installing in cow barns. The most common is the individual basin for each cow in which water is always present. Another system, where cement mangers are used, is a hydrant at one end and a drain that can be plugged at the other. After feeding the manger is swept out and the water turned in so the cows can drink. Then the water is drained out, so that at each watering time the cows receive good, clean, fresh water. When the cows are watered in an outside tank and they should get out for a short time each day—a tank heater should be provided.

WARMTH, LIGHT AND VENTILATION.

Warmth, sunshine, light and ventilation go hand in hand and all are of exceptional importance. The value of warmth has been referred to and in this connection it may be said that a barn well built and without cracks, in a sheltered spot, will, as a rule, be warm enough when filled with cows, the body heat given off.

Sunshine, light and ventilation, however, are not so easily attained. Barns built to run north and south are most desirable as they admit the most light and sunshine. Another advantage gained by building the barn on a line running north and south is that on warm days the doors at each end may be opened and the air of the barn quickly changed. In summer time this guarantees a cool barn. Windows should be large and placed close together, admitting all possible light and sunshine. Light and sunshine are death to germs.

As for ventilation, perhaps the King system, properly installed, is best. This system is simple and consists of fresh air intakes at the ceiling of the barn and foul air outlets at the floor. The outlets extend from the floor to the cupola of the barn and should be lined with tarred felt or paper to make them air tight. The principle on which the King system operates is that foul air is heavier by 15 per cent than fresh air and settles to the floor and is conveyed from the barn through the outlets on a level with the floor as the fresh air enters the intake flues. Another plan which promises to be successful is to use the same outlets for foul air and insert muslin instead of glass in a number of the windows. Still another plan which seems to be very efficient is to have intakes in the side of the barn or windows and have the outlet shaft reach nearly to the floor, the lower part being either of canvas or so constructed as to telescope and thus raise or lower.

SANITARY CONDITIONS.

Because in the dairy barn feed for human consumption is being produced and because milk readily takes up impurities, it is very

important that sanitary conditions and methods prevail in and about the barn. The public is beginning to realize that there is a great difference between pure and impure milk, and many cities are fighting persistently against the sale of impure milk.

Considering these facts it becomes at once apparent that it is to the dairyman's advantage to produce a pure, wholesome commodity, and to do this his barns, cows and attendants must be clean. All floors, feed mangers and gutters should be of cement and kept scrupulously clean. Gutters, furnished with drains for conducting liquid manure to a cess pool, should be built behind the cows. The cows themselves need daily grooming and udders, teats and flanks should be sponged off before each milking. Milk-ers and every one who handles milk must be clean. White laundried suits worn while milking and caring for the milk will be a great source of cleanliness. The milk room should at least be separated from the barn by a corridor to prevent odors from entering it. It should have cement floor and walls that can be easily kept clean by washing. Plastered walls are unsatisfactory as steam and moisture and jar of machinery cause plaster to crack and fall. Whitewashing the interior of the barn at frequent intervals serves not only to make the barn lighter but also destroys many germs. It may be said in this connection that the fewer and simpler the furnishings and equipment in the barn the easier it is to keep clean. For this reason gas pipe partitions in stalls and swinging iron stanchions hung in gas pipe frames are much superior to complicated patent stalls; and, too, they are more comfortable for the cow and keep her cleaner, points well worth considering. The same sanitary conditions are worth observing in the calf pens because dirty surroundings are directly accountable for many of the troubles experienced from calf scours.

CONFINEMENT OF ODORS.

About the dairy barn there are many distinct odors and these must be confined to themselves to prevent the milk from becoming contaminated. Silos have an odor peculiar to themselves and should be built away from the barn and connected with it by a corridor, the door of which can be kept tightly closed. With this precaution, and by feeding silage only after milking, the milk will not be tainted nor taste of the silage flavor. The calf barn has still another peculiar odor and for this reason should be set off from the cow barn. Hay, though without any bad odor, is dusty. The hay chute, therefore, should be a closed apartment and large enough to permit a large amount of hay to be thrown down from the mow at once. After the dust has settled the door may be opened and the hay distributed among the cows. This keeps much dirt out of the barn. The feed room, too, should be a tightly closed room for the same reason.

The cow barn itself has odors not agreeable when found in milk, so the milk room needs to be a distance from the barn. Many milk plants have their milk rooms many yards from the barn and carry the milk in cans over a cable. At least five feet of space should separate the milk room from the barn; this too may be connected with a corridor fitted with swinging doors,—two sets, preferably.

Bulls also have a distinct odor, and more than this, they are very troublesome when housed in the same barn as the cows. For these reasons it is advisable to have a separate place for them a goodly distance away. A shed opening into a small pasture of an acre and a half per bull is best. He can go in and lie in the shed out of the hot sun or cold winds and storms or he can remain in the pasture. Unless the weather is very severe he will choose the latter, which is best.

To make a cheap addition to the capacity of the dairy farm it is well to have a shed for dry cows, yearlings, heifers, etc., when not in milk. These animals will otherwise take up expensive room in the cow barn proper when they would be better off in the open air, sheltered from exposure by a cheap, warm shed where they will not detract from the appearance of the milking herd. This shed is best located so that it will be conveniently accessible from the silos, hay room and feed room of the main barn, as the cattle there kept can be well fed with little labor.

THE KIND OF FLOOR.

The features of a good floor for the dairy barn are:

1. Impervious to moisture.
2. Sanitary and easily cleaned.
3. Comfortable for cows.
4. First cost not too great.
5. Durable.

The following floors are in common use in dairy barns:

1. Dirt with cement or wood gutter.
2. Wood.
3. Brick.
4. Cement.
5. Cork Brick.
6. Creosote Blocks.
7. Planks dipped in creosote.

The dirt floor with cement or wood gutter is cheap and comfortable; however, it takes up moisture and is not very easily cleaned. It is superior to the wood floor in nearly every respect, especially if made with clay that will pack firmly. Brick floors are not very desirable and as they are rather expensive are used but little at the present time. Cement is the material which comes nearest the requirements for the dairy barn. It is impervious to moisture, sanitary and easily cleaned, the cost is not great and if properly constructed it is very durable. However, it should not be too smooth or the cows are likely to slip and be injured. Furthermore, the cement floor is hard and unyielding and unless a generous supply of bedding is used during the cold weather, udder troubles may occur from contact with the cold cement. These objections may be readily overcome by putting cork brick or creosote blocks on top of the cement in the cow stalls. Either will be found to be very efficient and valuable, but it is impossible to make definite statements concerning their relative durability as they have not been in use long enough.

Planks dipped in creosote are quite an improvement over the undipped planks but not equal to the cement with the cork brick or

creosote block in the cow stalls. It is a good idea to have the cement wall extend up to the bottom of the windows, care being taken not to leave a corner or crack for the accumulation of dirt at the junction of the floor and wall.

ARRANGEMENT OF LOTS AND PASTURES.

On the dairy farm are old bulls, bull calves, cows in calf, open cows, heifers in calf and those not, and heifer calves. Pastures and grass lots should be provided for each of these classes of animals. No worse mistake can be made than to permit cows heavy with calf and cows that are liable to come in heat to run together. Those in calf are liable to be caused to abort and much loss is thus occasioned. Cows in heat should be at once removed to a separate small pasture until this period is over, for even after considering abortion, such animals may cause cows milking heavily to fret and fall away greatly in their milk flow. Young heifers and heifer calves do best when kept separate and to themselves, for dairy animals come in heat very young and if running with older animals they are likely to be broken down and ruined at such times. Because of this hot-blooded characteristic, heifer and bull calves should be kept separate after they are three months of age. Many instances are on record where dairy bred heifers have become accidentally impregnated and practically ruined when only three months of age. Lots and small pastures are very convenient and it is doubtful whether it is possible to have too many of them on the dairy farm.

What might be termed a night pasture is provided by many dairy-men to accommodate the milking herd during the night, close to the barn, so that in the early morning the cows can be quickly got in and milked without wading through wet grass.

DISEASES COMMON TO THE DAIRY HERD.

It should be stated in this connection that the services of a competent veterinarian are occasionally absolutely necessary and this veterinarian must be on the ground to know all the conditions and to diagnose and treat the case for best results. However, the following treatments have been found very efficient and should be known by all who work with dairy cattle.

SCOURS OR WHITE SCOURS.

A treatment which was first used and recommended by Dr. L. A. Klein of the South Carolina experiment station, and which is efficient both for ordinary and white scours, is as follows: One part formalin to 4,000 parts milk. This dilution may be obtained by making a stock solution of one-half ounce of formalin to fifteen and one-half ounces of water. From this stock solution one teaspoonful is added to each pint to be fed the affected calf.

A mixture of equal parts salol and bismuth sub-nitrate may be given in connection with and preceding the formalin treatment. A dose of this powder would be about one-fourth of a teaspoonful and should be placed well back on the calf's tongue just prior to giving the milk. This treatment may be repeated on the second day if necessary.

Another treatment in case the scours are due, solely to indigestion is to reduce the feed and give the calf from one and one-half to two tablespoonfuls of castor oil, repeating the dose on the second day if necessary. Scours in very young calves may be due to the fact that the mother's milk is too rich in butter fat and a change is necessary.

ABORTION. (Sinking the Calf.)

Abortion is the term used for the expulsion of the unborn calf at any time before the completion of the full period of pregnancy. It usually occurs at those three week intervals at which a cow would be in heat if not pregnant. In cows abortion may be either contagious or non-contagious. In case one is not sure, a blood test may be made to determine whether or not contagious abortion is in the herd. Information concerning this test may be secured from a competent veterinarian or by writing to the Veterinary division, Iowa State College, Ames, Iowa.

Non-Contagious Abortion: Poor condition, weakness, and a too watery state of blood may be a predisposing cause. This may result from poor or scanty feed, excessive drain on the udder while bearing the calf or from feed deficient in certain elements. Slopping, slippery stalls, deep gutters, crowding at feed rack, gate or tank, excitement, offensive odors and irritant poisons are among the causes. Of the last, ergot is one of the most active and common.

Contagious Abortion: Contagious abortion spreads very rapidly in a herd and unless extraordinary care is exercised it is very hard to get rid of. It is due to the presence of a germ which may be easily transmitted from one animal to another.

DIRECTIONS FOR THE TREATMENT OF AN ABORTING HERD.

1. Burn the aborted foetus and membranes. This material carries the germs of abortion in abundance and burning or deep burial furnishes the only means of getting rid of it in a safe way.

2. Isolate discharging cows. The vaginal discharge from cows that have aborted is very virulent and may furnish the means of infecting other cows. Hence, discharging cows should be kept apart from the herd.

3. Disinfect the premises. This procedure should be executed with the most exacting care. Partial or inefficient disinfection is practically useless. To disinfect, where fumigation with the vapor of formaldehyde cannot be employed, the spray pump furnishes the best means. It should be borne in mind that disinfectants do not destroy germs that they do not come in contact with. So all large accumulations of bedding, forage and manure should be removed and every place that may harbor a germ should be reached with the disinfectant. Especial care should be used to drive it into every crack, knothole, behind every loose board, on top of every beam and into every partly concealed hole as well as upon every exposed surface. A five per cent solution of good (not crude) carbolic acid may be used for this purpose.

Following the disinfection by spraying and the cleaning of the stable, it may be whitewashed with limewater containing one pound

of fresh chloride of lime to each three gallons of water. This may be applied with a brush, or, better still, with a spray pump.

The barn yard should be well cleaned out, the manure being spread in some field that the cattle do not have access to.

4. Irrigate the genital passages of the cows that have aborted. This may be done by means of a funnel and a rubber hose five-eighths of an inch in diameter and about four or five feet long. Insert the hose into the vagina and, if possible, into the uterus of the cow. Allow from three to four quarts of the warm solution to flow into the cow and out. Take a fresh hose and irrigate the next cow, allowing the first hose to soak in an antiseptic solution in the meantime.

This treatment should be repeated every second or third day so long as there is any discharge from the cow. Afterwards it may be used once or twice a week.

There are many solutions recommended for this purpose. A very safe and efficient one being a one per cent solution of permanganate of potash. This solution may be made by using one tablespoonful of the crystals to three gallons of luke warm water.

5. Irrigate the sheath of the bull. The purpose of flushing out and disinfecting the sheath and the outside of the penis of the bull, is to prevent him from carrying the germ of abortion from one cow to another. This procedure should be enforced before and after each service. This is very important. The sheath may be flushed out by using a small rubber hose and funnel, or by the use of a small syringe. The end of the hose is to be inserted into the sheath beside the penis, the foreskin is held together with the fingers and the antiseptic is poured into the funnel.

6. The long hair at the end of the bull's sheath should be cut off. Moreover it is well to clip the hair from under the belly over a circle one foot in diameter surrounding this opening of the sheath. Then, by washing with a sponge, this area can be easily cleaned before each service.

7. Wash off the external genitals of each cow every day. For this purpose use any of the antiseptics recommended above. They can be applied with a clean sponge. The parts washed should comprise the root of the tail, the anus, the vulva and the surrounding skin for a distance of several inches, and the corresponding portions of the tail. A separate bucket and sponge should be used for the cows that are pregnant and those that have recently aborted.

8. Do not breed a cow for about ten weeks after she has aborted. About ten weeks are required for the thorough treatment of a cow that has aborted and she should not be bred before the expiration of this period. If she shows any discharge or other indication of vaginal catarrh, she should not be bred for a longer period, or until the parts are in entirely normal condition. The last injection two days prior to service should be a two per cent solution of bicarbonate of soda.

9. A solution of carbolic acid may be administered subcutaneously to each pregnant cow. For this purpose use a three per cent solution of carbolic acid, and of this inject two drams every ten days. Should this cause swelling in some individuals, for

these use a smaller amount. This treatment is highly recommended.

Salt Mixture. A mixture made up as follows is highly recommended by a number of the leading dairy farmers and may be used in connection with treatment number 9; ten pounds of sulphur, six pounds copperas, three pounds saltpetre, three pounds air slacked lime, one pound asofetida.

One pound of the above mixture is mixed with each ten pounds of salt and place where the animals can eat what they desire.

The herd on the college dairy farm was handled in the manner outlined above upon the outbreak of contagious abortion a few years ago and the trouble soon ceased. The above treatment, except the use of the salt mixture, was recommended by members of the Veterinary Department of Iowa State College.

METHYLENE BLUE TREATMENT.

In bulletin No. 174 from the Vermont Experiment Station Dr. F. A. Rich reports that by beginning early in pregnancy the use of methylene blue, infectious abortion may be stopped. He states that, "10 to 15 grains (1-3 to $\frac{1}{2}$ oz.) doses (in capsules) should be given night and morning for seven days, and that after a four weeks' interval the treatment should be repeated for another seven days and continued at four week intervals during the period of gestation." It may be administered by introducing the capsules into the throat by means of a balling gun. It is important that medicinal rather than commercial methylene blue be used.

MILK FEVER.

Milk fever is of frequent occurrence and in cows giving large quantities of rich milk much precaution is necessary and very close attention is important the first forty-eight hours after calving.

The feeds used should make the digestive system cool and act as a laxative and the cow should not be placed in a draughty stall or given cold water to drink. The indications of milk fever are as follows: Restlessness, stamping of the feet, throwing the head, wild appearance of the eyes with dilated pupils and bellowing. These symptoms soon give way to muscular weakness. The animal staggers, loses power of standing and falls to the ground. Unless quickly attended the cow throws her head around on one shoulder and soon enters a comatose state. When the first symptoms appear the udder should be filled full of air with a milk fever outfit made for the purpose and all feed should be kept from the cow for a time. Neither should she be drenched while in this condition. Great care should be exercised to properly sterilize the teat tubes, and all that comes in contact with the udder owing to the danger of infection. Full directions accompany each milk fever outfit and one of these outfits should be on every dairy farm.

GARGET.

Garget is of very common occurrence. It may be caused by heavy feeding or the cow catching cold in her udder from lying on cold ground or floor. To remedy the trouble reduce feed, giving only such feeds as bran, oats, and oil meal; give a dose of salts or raw linseed oil, and massage the affected portion of udder with a mix-

ture of equal parts of sweet oil and Goulard's extract. In severe cases applications of antiphlogistine are very effective. Oftentimes it is necessary to open up obstructed teats to prevent loss of a quarter. This should be done by a competent person with a sterilized instrument made for that purpose.

INDIGESTION AND BLOAT.

This occurs very frequently. For the former, feed should be reduced and a pound of salts or a quart of raw linseed oil should be given. In severe cases a veterinarian should be called or infection is likely to follow. For bloat the cow should be given a quart of raw linseed oil followed by a half pint of turpentine.

SORE TEATS.

Sore teats may result from various causes. They are oftentimes caused by wet hand milking, which is a filthy method and should not be allowed by either the owners of cows or the consumers of dairy products. Applications of olive oil or carbolized vaseline will be found very efficient in treating sore teats and in removing small warts. In the case of warts it is sometimes necessary to clip off the ends and apply lunar caustic.

COW POX.

In cow pox little pale red nodules appear on the teats. The milk flow decreases and soon the eruptions form into blisters which become filled with a straw colored pus. The milking should be done gently and the sore teats washed with a solution of half an ounce of hypo-sulphite of soda in a pint of water.

BITTER MILK.

Bitter milk is sometimes produced by nearly all the cows in the herd. In these cases it is usually caused by the feeding of hay containing weeds, or pasturing the cows in a weedy pasture although it may be caused by bacteria coming in contact with the milk after it is drawn. Some cows will produce bitter milk after milking for several months. Such cows should be dried off and if the same trouble appears during the next lactation period, disposed of.

STRINGY MILK.

This condition does not occur very frequently unless the cows drink water from stagnant pools, etc. By giving the cows access to pure water only and by giving each affected cow two drams of bisulphide of soda daily. Dr. Law states that the trouble may be permanently arrested.

BLOODY MILK.

This condition may result from various causes such as bruises, eating irritant plants, diseased or inflamed udder or eating too rich food.

TUBERCULOSIS.

It is needless to say that a tubercular free herd should be maintained. The herd should be tested annually by a competent veterinarian and all reacting animals should be disposed of. It is best to have a quarantine building in which to place suspicious animals for ninety days and then give them a retest as a slight rise in temperature may be due to some other cause.

AVAILABLE BULLETINS

The following bulletins and circulars of the Iowa Agricultural Experiment Station are available for distribution to Iowa farmers and may be secured while the supply lasts by a request to the Bulletin Editor, Ames, Iowa.

- No. 82. The Principal Soil Areas of Iowa.
- No. 88. The Vitality, Adulteration and Impurities of Clover, Alfalfa and Timothy Seed for Sale in Iowa in 1906.
- No. 92. Tuberculosis in Swine.
- No. 93. The Comparative Value of Alcohol and Gasoline for Light and Power.
- No. 95. The Maintenance of Fertility with Special Reference to the Missouri Loess.
- No. 107. Methods of Detecting and Controlling Tuberculosis.
- No. 109. The Value of Corn, Oilmeal, Cottonseed Meal, and Gluten Feed in Work Horse Rations.
- No. 110. Roots and Corn Silage for Fattening Lambs.
- No. 112. Do Sugar Beets and Mangles Cause Kidney and Bladder Stones?
- No. 114. Plum Varieties.
- No. 119. Gumbo Soils.
- No. 120. Catalpa Growing in Iowa.
- No. 121. Creamery Bookkeeping.
- No. 122. The Wheat Head Army Worm as a Timothy Pest.
- No. 124. A Centrifugal Method for the Determining of Humus.
- No. 127. Spraying Practice for Orchard and Garden. (Second edition)
- No. 130. The Pear Slug.
- No. 135. The Germination Test of Seed Corn.
- No. 136. Forage Crops for Swine.
- No. 137. Alfalfa Management in Iowa.
- No. 138. Silver King—A Corn for Northern Iowa.
- No. 139. Creamery Organization and Creamery Construction.
- No. 140. Lacto.
- No. 141. Silo Construction.
- No. 142. The Wood-Using Industries of Iowa.
- No. 143. Hogging-Down Corn—A Successful Practice.
- No. 144. Cold Storage for Iowa Grown Apples.
- No. 145. The Effect of City Smoke on Vegetation. (Ready April 1.)
- No. 146. The Result of Seed Investigations for the Years 1910-13 (Ready April 1.)
- No. 147. The Coddling Moth in Iowa. (Ready April 1.)

CIRCULARS

- No. 1. Home Made Seed Corn Testers.
- No. 2. Liming Iowa Soils (Second edition).
- No. 5. Unlawful Weeds and Their Extermination.
- No. 6. Feeding Corn Silage to Farm Animals.
- No. 7. Bacteria and Soil Fertility.
- No. 8. The Inoculation of Legumes.
- No. 9. Farm Manures.
- No. 10. Green Manuring.
- No. 12. Soiling Crops to Supplement Iowa Pastures.
- No. 14. Some Common Internal Parasites (Worms) of Hogs and Their Treatment.
- No. 15. Testing Soil in Laboratory and Field.
- No. 16. The Feeding, Care and Management of the Dairy Herd.
- No. 35. Press Bulletin—Tuberculosis in Farm Poultry.

EXTENSION DEPARTMENT BULLETINS

- No. 5. Establishing the Apple Orchard.
- No. 8. Potato Growing in Iowa.
- No. 11. Bee Keeping in Iowa.
- No. 13. Co-Operative Cow Testing Associations in Iowa.
- No. 15. Waging War on Hog Cholera.
- No. 16. Conducting Agricultural Exhibits and Contests.
- No. 17. Home Furnishing.

REARING CHICKS SUCCESSFULLY



AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Poultry Section

Ames, Iowa

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REARING CHICKS SUCCESSFULLY

BY R. M. SHERWOOD.*

Rearing chicks has its serious problems, but the young brood may be brought successfully through the first six or eight weeks if these essentials are followed:

- 1.—Give chicks a good start by selecting strong, vigorous, well-matured breeding stock that is free from disease and has been properly housed and fed, and by properly incubating the eggs from the stock.
- 2.—Make sure that hens used for brooding are free from lice and mites before the chicks are placed with them.
- 3.—If an artificial brooder is used, make sure
That it will provide ample heat without danger of fire,
That it gives the chicks a chance to get away from the heat when they want to,
That it has a capacity large enough,
That it is economical in its cost and in the fuel it uses.
- 4.—Remove dead chicks promptly from the brooder and bury them deeply or burn them.
- 5.—Mark all weak chicks so that they will never be used as breeders.
- 6.—Clean the brooder and disinfect it each time before it is used and oftener if disease breaks out in flock.
- 7.—Do not feed chicks until they are from 48 to 60 hours old, and then only limited amounts of easily digested food for the first week.
- 8.—Use only clean and wholesome food and feed it only in clean dishes and litter.
- 9.—Provide a variety of feeds. They should contain enough of protein and ash. Ground bone furnishes ample ash and some protein; skimmed milk and buttermilk furnish abundant protein.

MANAGEMENT BEFORE THE CHICK IS HATCHED.

The greatest success in rearing chickens comes only when proper methods are adopted, even before the chick is placed in the brooder or out with the hen. It is generally conceded that factors which lower the per cent of the hatch will also lower the strength of the chicks which hatch.

The breeding stock should be strong, vigorous and well matured. The hens must be properly mated, housed and fed, and be given every condition that will induce them to lay eggs which will produce strong

*Assistant Professor of Poultry Husbandry.

chicks. They should be free from disease. In some eastern states a heavy loss of chicks is caused by bacillary white diarrhoea. It has been found that this disease may come to the chicks from the hens in the breeding flock.** If a female chick recovers from the acute form of this disease and matures, its ovary will carry the infection and the chicks produced from the eggs laid by such hens will have the disease. Thus the trouble may go from hen to egg, from egg to chick, from chick to pullet, and so on, generation after generation.

For the first four or five days after the chicks are hatched the acute form of bacillary white diarrhoea is very readily transmitted from one chick to another. After this time it is less readily transmitted, but there is good evidence that it is still contagious and the adult stock may become infected and transmit the disease at least through the female line, as previously noted. It is probable that this disease is not very common in Iowa; it is important, however, in buying eggs or chicks to know that they are free from it. It is a good plan to note the ovaries of the hens that die or are killed on the farm, because ovaries that are distinctly abnormal in appearance are always found in hens that carry the infection.

A great loss in chicks is also often due to poor incubation and handling of eggs before incubation. The moisture content of the incubator is of almost as much importance as the temperature. At hatching time great care is necessary not to allow the chicks to become chilled. The temperature of the nursery chamber in many incubators is several degrees cooler than the egg tray, and for this reason the chicks should not be allowed to drop down to the nursery chamber until they are thoroughly dry. A wet chick chills much more readily than a dry one. If a chick becomes chilled, bowel trouble is almost sure to follow, and with that great loss results.

Lice and mites are the cause of a great loss in hen hatched and hen brooded chicks. To reduce this loss the sitting hens should be thoroughly dusted at the beginning of each week of the incubation period with a good louse powder. A good powder may be made at home as follows:

Three parts gasoline, 1 part commercial cresol. Add to the mixture of these liquids as much plaster of paris or land plaster as the mixture will moisten. Allow to dry.

To use this powder, apply liberally to the hen, especially around the vent, under the wings and the breast. It is much simpler to reduce the number of parasites on the hen than to have to work with all the chicks. This powder is too severe for young chicks.

EQUIPMENT FOR ARTIFICIAL BROODING.

One of the first essentials for a good brooder is that it will at any time give a temperature under the hover of 95° to 100° without danger

**Storrs Experiment Station, Storrs, Conn.



Fig. 1. A Colony Brooder House.

of fire. A large number of the brooders on the market are not capable of doing this in the early spring months unless they are in buildings with some auxiliary heating system. As chicks are injured by being overheated as well as by being chilled, there should be some provision made so that the chicks may get away from the heat if they are too warm. Such a hover makes it possible to keep the chicks warm during cold nights without overheating them, for they may get far from the heater in the warmer evening and nearer to it as the night gets colder.

In building the brooder house care should be taken to have ventilation without much circulation of air near the floor. Provision is also necessary for admitting an ample supply of sunlight as it helps to keep the house free from disease and makes the chicks contented.

The house and brooder should be large enough so that the flock will not be crowded. It is common to recommend more chicks for a brooder than should be kept in it. Large colony houses have several advantages over small outdoor brooders; they are not so quickly affected by outside conditions; they do not cool off so quickly if the door is opened, and they may be used for other stock when not needed for brooding. The most satisfactory house is one in which the work may be

conveniently done and preferably one large enough for the caretaker to enter. The matter of convenience is important to consider in selecting a brooder also. Ready access to the floor should be provided so that it may be easily kept in good condition.

Of the brooder houses used at the Iowa State College poultry farm, the 8x10 foot house with a double pitch roof, as shown in figure 1, is one of the most efficient. It is large enough and so constructed that when not used for a brooder house it is very satisfactory for hens, cockerels and capons. It gives ample floor space for 200 chicks, it has openings enough at the front for sunlight and ventilation without drafts. It is convenient and is not affected by climatic conditions as are the small outside brooders.

The illustration shows these openings. They may be closed by glass windows or by frames covered with muslin. The openings are all the same size and thus the glass or muslin may be shifted from one open-

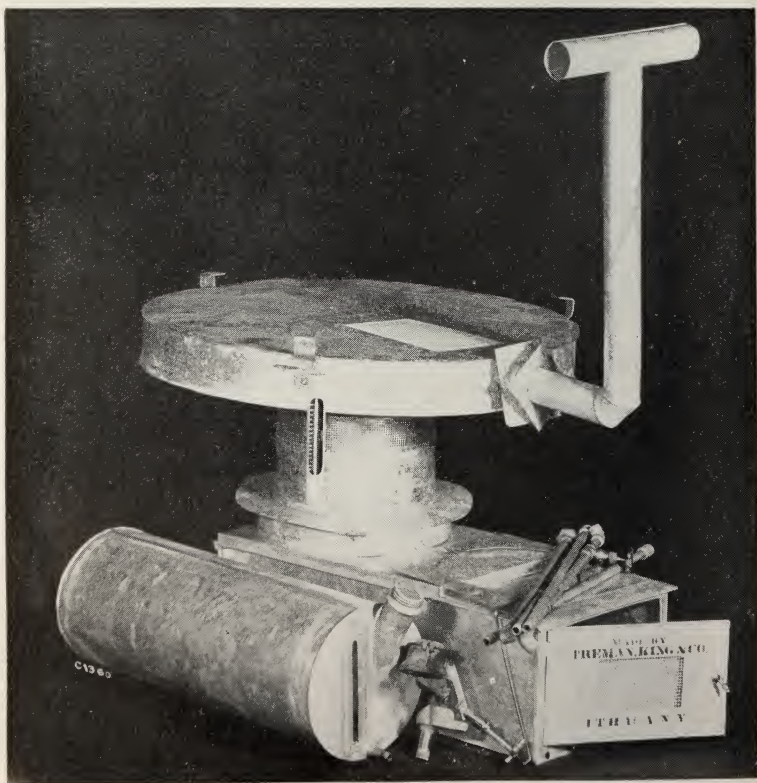


Fig. 2. The Cornell brooder-heater.



Fig. 3. Cornell brooder with hover raised.



Fig. 4. Cornell brooder with hover down, showing device to keep chicks close to the hover.

ing to another as the age of the chicks or the climatic conditions may demand.

A brooder which has proven very satisfactory and which has a true capacity of 200 chicks is the one worked out by Cornell University.* It is a non-patented heater and for this reason may be made by any one. The fuel used is gasoline. The advantage of this heater is that the troublesome wick is done away with. The flame is regulated by means of a metal valve and the entire heating device is metal so that the danger of fire is largely eliminated. Other advantages of this gasoline brooder, aside from being safe, are that it cares for a sufficiently large number of chicks to economize fuel and labor, that it will keep the chicks warm in rather severe spring weather, that it is easily operated and regulated, that the hover is large enough so that the chicks may get away from the heat when desirable, and that it is convenient.

Fig. 2 shows the brooder heater furnished by the manufacturer. The burner box and radiator are set up to show the way in which they are connected when in use. Fig. 3 shows the heater installed with the hover raised to show the arrangement of the different parts; note the position of the gasoline tank. Fig. 4 shows the hover in position for brooding, also the device used to keep the chicks near the brooder until they have learned to go under the hover. This device may gradually be moved farther from the brooder and finally taken away altogether. The side of this device nearest the brooder is made at right angles with the floor while the one on the outside slopes so that any chick that should get over may easily get back.

GENERAL MANAGEMENT FOR ARTIFICIAL BROODING.

It is important that finely chopped litter be placed on the floor or the brooding house as well as a liberal supply under the hover to protect the chicks from the cold floor. The brooder should be started long enough before the chicks are to be placed in it to warm and dry out the hover and litter and to enable the operator to become sufficiently familiar with its operation to regulate the temperature properly. The temperature should be from 95° to 100° for the first week and then gradually decreased as the chicks grow older and the season advances. It is impossible to say how fast to lower the temperature except to notice the chicks. At night, if the temperature is correct, the chicks will be spread out asleep on the floor under the hover. If it is too cold they will be crowding together and chirping.

Whenever caring for the chicks, the operator should look under the hover to find and remove any dead chicks or any which may be sick. All dead chicks should be burned or buried deeply and the sick or weak ones should either be killed or taken away from the others. Should they recover, they should be marked and never used as breeders. As soon as the sex may be distinguished, mark the weak pullets and the strong, vigorous cockerels. Send the weak pullets to market and use only the strong cockerels for breeders. It is easier

*Sold by Treman, King & Co., Ithaca, N. Y.

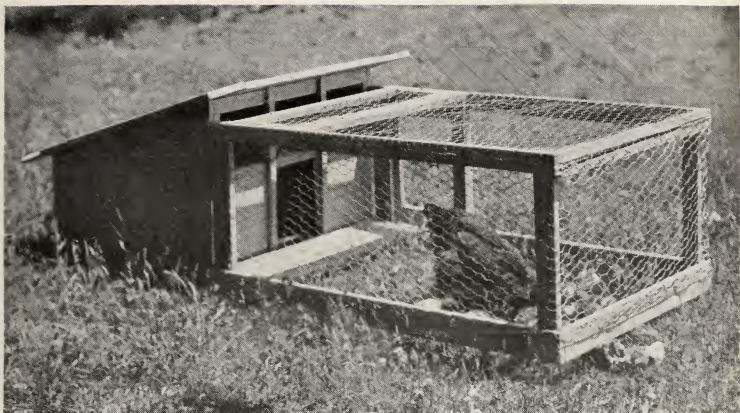


Fig. 5. Coop and pen for natural brooding.

to judge the strength and vigor of chicks when compared only with those of the same age than when a number of ages are together.

Thoroughly clean the brooder and brooder house and disinfect them each time before chicks are placed in them. If a disease is known to have been present the brooder and house should be thoroughly scrubbed and allowed to dry before being disinfected. A strong mixture of almost any of the coal tar dips is satisfactory for disinfection, or a home made disinfectant may be made as follows:

Shave 1 ten cent cake of laundry soap into 1 pint of soft water. Heat or allow to stand until soap paste is formed. Stir in 1 pint of commercial cresol and heat or allow to stand until the soap paste is dissolved. Stir in 1 gallon of kerosene. This may be used diluted with 10 to 50 gallons of water.

EQUIPMENT AND MANAGEMENT FOR NATURAL BROODING.

A considerable amount of labor and trouble may be saved by hatching at one time as large a proportion of the chicks as it is intended to raise as is practical. Almost always more chicks may be brooded by a hen than she will hatch at one time; thus some of the hens that were used for incubating may be reset or returned to the laying flock. Chicks of different ages must be kept separate if best results are to be attained.

When chicks are brooded with hens, small coops are desirable. Almost any of the small coops seen on farms are very satisfactory for confining the hen when the chicks are to be allowed their liberty. A good coop for hens may be made by covering a framework made of strips or waste lumber with a good grade of roofing paper. It is often necessary to keep the chicks confined during rainy weather or in the morning when the grass is wet. For this purpose a coop with a pen similar to the one shown in figure 5 is very satisfactory.

When the chicks are running at large the pen may be set on blocks or bricks and be used to feed the small chicks and exclude the larger ones.

CHICK FEEDS.

Every food used in a ration for chicks should be clean and wholesome. The feeding of musty grains or tainted meat feeds results in serious bowel troubles. Tainted feeds may be detected more readily by holding them tightly in the hand for a short time until they become warm. If a putrid or decayed odor is found in meat feeds they should not be used; however, a cooked or burned meat odor is present in a good grade of this product.

The cost of the ration is important in all animal feeding. It is, however, least important in chick feeding, for only a small amount of food is required to bring chicks through the brooding period.

The chick ration should contain a variety of feeds and be made up of cracked grains, ground grains or mill feeds, animal feeds, green feeds and mineral feeds. The kinds of cracked grains and ground feeds selected will depend upon their availability and price. In Iowa, where corn is one of the cheapest feeds, it should make up a large part of the ration. This feed must be supplemented by feeds rich in protein and ash. High grade meat meal, beef scrap, sour skimmed milk, buttermilk, and infertile eggs, tested from the incubator, are rich in protein. Although it is commonly recommended to hard boil the eggs to be used in chick feeds, such a practice makes the eggs less readily digested. Raw eggs are fed at this college with very good results. If bacillary white diarrhoea was known to be present, the eggs should be boiled to kill any germs they may contain. Sour skimmed milk and buttermilk can advantageously be used to make the moist mash as well as for drink. This, however, will not take the place of water, which should always be provided. Although meat feeds, milk and eggs are rich in ash, ground bone should also be provided.

For the necessary green or succulent feed, young clover or alfalfa are excellent. Sprouted oats may be fed if the above feeds are not available. Some poultrymen plant lettuce for chicks.

The ground grains or mill feeds should be combined in such proportions that the ration will be crumbly and not sticky or pasty. A sticky or pasty ration is not easily digested and also causes disorders of the digestive tract.

No one ration can be recommended as the best for all conditions. The following two are submitted, one of which proved satisfactory in experiments at Cornell University and the other is used with success at Iowa State Experiment Station. Either may be used advantageously when the ingredients are all available. In other cases substitutions may be made:

RATION I.

CRACKED GRAIN.

First four weeks.

Cracked wheat 3 parts
 Finely cracked corn 2 parts
 Pin head oat meal 1 part

Fed twice a day.

For later feeding.

Whole wheat 3 parts
 Coarsely cracked corn 2 parts
 Hulled oats 1 part

GROUND FOOD.

First four weeks.

Wheat bran 7 parts
 Alfalfa meal 2
 Corn meal 3
 Wheat middlings 3
 Sifted beef scrap 4
 Ground bone 1

For later feeding.

Wheat bran 3
 Alfalfa meal 3
 Corn meal 3
 Wheat middlings 3
 Beef scrap 4
 Ground bone 1

The ground food is moistened with skimmed milk and fed three times a day at the start and decreased as the chicks grow older. Beef scrap is hopper fed at all times.

RATION II.

CRACKED GRAINS.

Grain ration "A" fed first 8 weeks.

Cracked corn 2
 Cracked wheat 1
 Steel cut oat meal 1

Fed twice daily in litter from one to six inches deep.

Grain ration "B" fed after the 8th week.

Coarsely cracked corn 2
 Wheat 1
 Oats 1

GROUND FEED.

Mash ration "C" fed first two weeks.

Stale bread 3
 Oat meal 3
 Eggs (tested from incubator) 4
 Bran $1\frac{1}{2}$
 Corn meal $1\frac{1}{2}$
 Ground bone $\frac{1}{2}$

Mash ration "D" fed after the second week.

Corn meal 3
 Wheat middlings or high grade shorts 2
 Wheat bran 1
 Beef scrap 1
 Ground oats 1
 Ground bone $\frac{1}{2}$
 Salt $\frac{1}{10}$

Ground feed made moist with sour milk and beef scrap or meat meal fed in hoppers.

SYSTEM OF FEEDING.

While the chick is developing in the egg only about one-fourth of the yolk is used; the remaining three-fourths is taken into the abdomen of the chick just before it hatches. This is sufficient material to maintain the life of the chick for a number of days. It is thought that too early feeding is often the cause of a failure of the chick to



Fig. 6. A satisfactory dry mash feeder for chicks.

properly absorb this material and a consequent dérangement of the digestive system. Dr. F. P. Shaw, who has made an extensive investigation of this subject, says, "That the digestive functions of the stomach (of the chick) are developed by the second day after hatching, whereas the pancreatic ferments are improperly developed before the seventh." The finding of Dr. Shaw explains the common practice of not giving chicks feed until two days old and then only giving them limited amounts of easily digested foods for the first week.

The following is the method of feeding used at this college: The chicks are generally taken to the brooder when 24 to 36 hours old or the first morning after all are hatched and thoroughly dried off. They may be given water, with the chill removed, and limited amounts of bone, charcoal and grit. Shaw says that grit, aside from aiding in grinding, also stimulates the muscular action of the gizzard, especially when large amounts of soft feeds are given. We can therefore see a double reason why grit should be supplied at all times.

After the chicks are 48 to 60 hours old they are given limited amounts of moist mash "C" and cracked grains, mixture "A". They are given no more than they will clean up in 10 or 15 minutes, but are fed moist mash five times a day for the first three or four days then reduced to four feeds, and at the end of the first week reduced to three feeds a day. When day-old chicks are shipped in, they should be put in the brooder at once and as soon as they are thoroughly warm, they should be fed the same as for the second day for chicks hatched at home.

The first feeds of cracked grains are fed on a shallow litter or in pans. The amount of this feed as well as the depth of the litter increases as the chicks grow older. At the end of the first week the litter is two inches deep. A dish of bran or hopper of dry mash is

kept before the chicks. Bone, grit and charcoal is also kept before them at all times.

By the end of the second week the number of feeds of moist mash is reduced to two and the depth of the litter is increased to three or four inches. As the number of feeds of moist mash decrease the amount of the cracked grain fed is increased.

During the third week the mash mixture "D" is gradually substituted for the mash mixture "C" and is fed moist two times a day until the end of the fourth week. The litter is now five or six inches deep.

From the fifth to the eighth week only one feed of moist mash is given daily and the same mash except dry is before them in hoppers. If the cockerels are to be sold as broilers they may be continued on the above feed until they are about ten weeks old, then they may be crate fattened for two weeks longer before being marketed. If they are to be caponized they may be run with the pullets which may be fed only dry mash in hoppers and the grain mixture "B" in the litter once a day. If early maturity is desired one feed a day of moist mash would be continued.

SANITARY PRECAUTIONS.

Fig. 6 shows a good dry mash feeder for chicks. Note the one inch mesh netting which lays on the feed to prevent the chicks from scratching it from the trough.

Throughout the entire brooding period the feed and water dishes should be kept clean and scalded often to prevent disease. For this same reason the litter in the pens should never be allowed to become filthy, but should be removed often.

Many feeders use potassium permanganate in the drinking water to prevent the spread of disease through the water supply. A stock solution is made by placing a couple of inches of the permanganate in the bottom of a wide mouthed bottle and then filling it with water. Enough of this solution is added to the drinking water to give it a wine color. Potassium permanganate may be purchased at a drug store at about twenty-five cents a pound and a pound will last the average poultry keeper a long time.

"IOWA 403"—A NEW SEED- LING APPLE

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Horticultural Section



"Iowa 403"---A New Seedling Apple

BY S. A. BEACH

One of the promising seedling apples originated at the Iowa Experiment Station is now offered to the nurserymen of the state under the label Iowa 403. It is hoped that the nurserymen will assist in making a thorough test of the variety, so that as soon as possible its value for planting in this region may be determined. The distribution at this time will consist solely of cions. Since the nurserymen, as a class, are prepared to give the cions more skillful attention than other people, this distribution is to be offered to all Iowa nurserymen whose names appear on the 1914 list of the State Inspector. Later distribution will be made to others who may be interested in testing this apple.

TERMS OF DISTRIBUTION

This variety is now offered without restriction as to further distribution by sale or otherwise. No charge is made for the cions but it is expected that those who receive them for testing will report results to the Station when called upon to do so. Only a few cions can be sent to each applicant. Requests will be filled in the order in which they are received. Applicants who do not get cions this spring will be listed for the next distribution.

Address all correspondence regarding this new apple to S. A. Beach, Horticulturist, Ames, Iowa.

DESCRIPTION OF THE FRUIT

The fruit of Iowa 403 is roundish conic and of medium size. It is a red apple. When well colored it is attractive but it does not equal Jonathan in this respect, being of a darker and duller shade of red.

The flesh is white or sometimes delicately tinged with a pinkish shade. The texture is moderately fine, firm, tender and crisp. It is sprightly sub-acid, having a little more acidity than Jonathan yet it is agreeable in flavor. In quality and flavor it easily ranks "very good", as grown in Central Iowa. It is desirable for either cooking or dessert uses.

The fruit may be kept until midwinter or later. It stands up well in shipment and storage. It is suitable for either home use or market.

DESCRIPTION OF TREE

The original tree, which is now 26 years old, stands in Station Orchard D on the black soil of the flat Wisconsin drift. In habit it is vig-

orous, upright and somewhat spreading. It has proven very hardy, not only in tree but also in fruit bud, as indicated by its productiveness in trying seasons. Even after the severe winter and spring conditions of 1910, which destroyed the apple crop in most parts of Iowa, it bore a little fruit. Some years it has loaded up so heavily that thinning would have been advisable. The following is its fruit record since 1907. This indicates that it is a reliable cropper under adverse climatic conditions.

- 1907. Crop fair.
- 1908. Crop 50 per cent.
- 1909. Crop 10 per cent.
- 1910. A few fruits.
- 1911. Crop 100 per cent.
- 1912. Crop good.
- 1913. Crop 100 per cent.

HISTORICAL STATEMENT

A few years ago the Horticultural section of the Iowa Experiment Station adopted the plan of designating the more promising seedlings produced in its plant breeding work by numbers prefixed by the word "Iowa", to indicate that they originated at the Iowa Experiment Station. The new apple which we are now considering was first recorded on the station lists as Russian Seedling No. 78 but later when it showed promise of being worthy of further testing it was called Iowa 403.

This apple was grown from seed collected in 1887 from an orchard at the Iowa State College which was then known as the Russian Orchard, but which later was called Orchard A. While this orchard was largely composed of Russian varieties imported by Professor Budd between 1878 and 1883, it also included numerous little known sorts of American origin and a limited collection of better known varieties, including the Canada Baldwin, Winter St. Lawrence, Haas, McIntosh, Scott Winter and others.

NEW APPLE NOT NECESSARILY OF RUSSIAN ORIGIN

The seedlings which were grown from the lot of seed above mentioned, were at first designated by number, following the word Russian, which referred to the name of the orchard from which the seed was taken. It is clear, therefore, that the designation "Russian 78" by which this apple was first listed in the station records, does not necessarily signify that it came from seed of any Russian variety. In fact, Iowa 403, shows no indication of Russian parentage but it does resemble Scott Winter noticeably in some of the characters of the tree and twigs and also in the hardiness of the tree and of the fruit bud and in the season of the fruit.

A few years ago this apple was sent under the label Russian 78 to some of the trial stations of the State Horticultural Society. It has

been fruited under that label by Mr. L. A. Clemens, Station Keeper at Storm Lake, and Mr. F. O. Harrington, Station Keeper at Williamsburg.

TWO GROWERS' EXPERIENCES WITH "IOWA 403"

Mr. Harrington exhibited this variety at the Winter Short Course at Ames in 1914. The fruit averaged larger than Jonathan and was of a very fine, deep, dark red color. In the Annual Report of the Iowa Horticultural Society for 1913, p. 480, Mr. Harrington gives the following report on the variety as grown at Williamsburg:

"RUSSIAN No. 78: Some apple cions were received a few years ago, from, if my memory serves, our agricultural college, under the above label. They were top grafted on a small Northwestern Greening. The tree has been bearing three years now. In 1911 perhaps only two or three dozen, last year possibly a bushel, and this season about two and one-half bushels. The tree has a little of the Jonathan characteristics, but perhaps more of those of the King David, not a trace that I can discover of the Russian types in the tree nor yet in the fruit, and am inclined to believe that if there is any Russian blood in it the American blood is so predominant in its essential characteristics as almost to eliminate any other. Apparently the tree will be a good bearer. Color of the apple is a deep red, darker than Jonathan; is larger than Jonathan, yet only medium size. In shape a little more elongated and conical than Jonathan. Calyx cup small and shallow. Flesh is firm and heavy, though tender and breaking and the quality very good for dessert uses. The flavor seems to be something of a blending of the Jonathan and Winesap. It appears to be worthy of a name and a test for a place in the commercial orchard."

Mr. Clemens has fruited Iowa 403 at Storm Lake. His orchard is 67 miles north and 180 miles west of the Harrington orchard under quite different soil and climatic conditions. He rates the quality of the fruit as he grows it lower than Mr. Harrington does. Mr. Clemens says: "Russian 78 as I have it topped on Hibernial, bears soon, is productive and seems hardy; whilst not an eating apple, it is a good cooking apple. All in all, for the cold north it is worth setting. Keeps past midwinter".

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS.

THE CONTROL OF CHICKEN MITES AND LICE

By R. M. SHERWOOD, Assistant Professor of Poultry Husbandry.

The two very common parasites, the chicken mite and the chicken louse, are responsible for a very large part of the loss suffered annually by poultry raisers, yet they may be dealt with effectively.

The symptoms for these two pests are much alike. In severe cases they are as follows: The head and comb become pale, the bird looks sickly, its feathers become ruffled and may drop out, it becomes dumpish and thin, and, if it is a female, it may stop laying. Sitting hens may leave the nest; sometimes they die from the effects of these parasites. Generally, the fowls may be seen picking at their feathers as if to remove the insects.

To make sure of the presence of either lice or mites, catch the birds and examine them. The lice may be found on them either day or night; the mites usually attack the chickens at night only and during the day stay in cracks in the poultry house as well as in the droppings.

The following descriptions will help the poultry raiser to determine which of the pests is attacking his chickens:

THE CHICKEN MITE—DESCRIPTION AND HABITS.

The chicken mite (*Dermanyssus gallinae*), or "red mite," as it is sometimes called, is a small parasite about 1-25 to 1-20 of an inch in length. It is broader in proportion to its length than the chicken louse. The mite is naturally gray in color with dark spots, but after it has visited the fowl and has gorged itself with blood it takes on a reddish appearance. This explains why many people speak of the "red" and the "gray" mite. This insect has sharp mouth parts which it inserts into the flesh of the fowl at night to feed on the blood, returning for the day to cracks in the perches and building, also to any filth in the house. There are at least two exceptions to this habit, namely: in the case of sitting hens and also in the entire flock when the infestation is very bad. Then the mites may stay on the fowl the entire 24 hours. Mites lay their eggs in cracks about the perches and wall, also in the droppings. The young hatch out in a few days and grow rapidly for ten days when they are mature.

Treatment: Since mites leave the fowls by day and breed in cracks and filth, the methods of getting rid of them are simple. Clean up all filth and thoroughly disinfect the building and fixtures with one of the disinfectants described later. Repeat the treatment as often as necessary. Where the droppings are removed often and the house kept clean, there is much less trouble from mites. Sunlight, cleanliness and ventilation are three excellent preventatives.

THE CHICKEN LOUSE—DESCRIPTION AND HABITS.

The chicken louse (*Menopon pallidum*) is pale yellow to gray in color, about one-twentieth inch in length, and rather slender. It spends most of its time on the fowl, although occasionally found in the nest. The eggs or nits are found on the down feathers of the fowl, especially around the vent. They hatch in six to ten days into small pale colored lice. These are very active and at

once irritate the fowls. They feed on scabs and secretions from the skin, also parts of feathers. They do not have piercing mouth parts and therefore do not suck blood. The young lice mature quickly. They undergo 10 or 12 moults before reaching the adult or full grown state. Lice breed very rapidly. In eight weeks the third generation is mature and if all lived the offspring of a single pair of lice up to and including the third generation would number as high as 125,000 individuals. Therefore where poor management is practised, lice give enough trouble to cause unthriftiness and even death in the flock.

Treatment: As lice spend their entire life on the fowl, the treatment must reach them on the fowl, as well as disinfect the house. Two methods are common: Dusting fowls and using paste or ointment. Some dip their chickens, but this is not good for the fowls, and it requires much attention afterwards to prevent colds and other troubles of the respiratory tract. For that reason that method is not recommended. Dusting has long been used by most poultry raisers. The fowls are allowed to dust themselves in any wallow they may select and in addition to this the sitting hens and any other which may need any special treatment are given a thorough dusting of some good louse powder.

A number of good powders are on the market, including pyrethrum, but most of them are too expensive for large numbers of fowls. The home made powder given in this circular is very satisfactory and not expensive. Fowls should be given a second dusting about a week after the first to kill any lice which hatch from eggs laid before the first treatment was given.

The third method, namely the use of salves, or ointments, is becoming more popular. Such ointments as those made of equal parts of lard and cottonseed oil have been used on young chicks; mercuric ointment is used for mature fowls.

LICE AND MITE EXTERMINATORS.

Liquids.

Cresol Soap. Dissolve a ten cent cake of laundry soap in one pint soft water; heat or allow to stand until soap paste is formed. Add one pint cresol; beat or allow to stand until soap paste is dissolved. Stir in one gallon of kerosene. Dilute with ten to fifty parts of water and apply with spray pump or broom.

Cresol-Kerosene Paint. To three parts of kerosene add one part of cresol. Apply with brush as a paint.

White wash. Slack one peck of lime and dilute to 40 gallons. Add two pounds of salt and one gallon of a good stock dip. Apply with a spray pump.

Government White Wash. $\frac{1}{2}$ bushel unslaked lime—slake with warm water and cover during the process to keep in the steam. Strain the liquid through a fine sieve or strainer; add a peck of salt, previously dissolved in warm water, 3 pounds of ground rice boiled to a thin paste and stir in boiling hot 1.2 pounds of powdered Spanish Whiting and 1 pound of glue which has been previously dissolved over a slow fire. Add 5 gallons of hot water to the mixture, stir well and let it stand for a few days covered from the dirt. Apply with a brush while hot. One pint will cover a square yard.

Louse Powders.

I. 3 parts gasoline, 1 part cresol.

Mix together and add as much plaster of paris or land plaster as the above mixture will moisten. Allow to dry and apply liberally to fowls. This is rather strong for young chicks.

II. Pyrethrum powder may be purchased at drug stores and used to dust small flocks. It is somewhat expensive and loses its strength readily on being kept in the open for a short time.

Louse Ointment.

I. 1 part vaseline, 1 part mercuric ointment.

A piece about the size of a pea rubbed into the skin around the vent for body lice.

II. 1 part lard, 1 part sweet oil or cottonseed oil.

Applied sparingly to feathers of neck and under the wings for lice on chicks.

Making Old Orchards Profitable

(Abstract of Bulletin No. 153)



AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Pomology Section

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MAKING OLD ORCHARDS PROFITABLE

By LAURENZ GREENE

In many sections of Iowa apples can be grown successfully and profitably in a large way, provided the industry is carefully studied and its problems are dealt with correctly.

To furnish a basis for study, to get at the difficulties of orcharding in the state, and to help growers meet them successfully and put the industry on a more permanent and profitable basis, the Iowa Agricultural Experiment Station, in the summers of 1911 and 1912, made a survey of the orchards of Mills county. This county was chosen because it ranked first in apple production and in the percentage of tillable soil devoted to this crop, although Pottawatamie county had a larger total area of apple orchards. In the survey every phase of orcharding was investigated and the results are reported in this bulletin, with suggestions for meeting the various problems that arise in the industry, and particularly for saving and restoring old orchards to profitable production.

While this report is made up of recommendations for the orchards of Mills county it will apply to orchards in all parts of the state.

Iowa's rank as a fruit producing state, and the importance of the Missouri loess as an apple producing soil appear in these tables.

ORCHARD AREA IN MILLS COUNTY

Table III gives the number of apple trees in Mills county for 1909 as 242,466. Estimating the average number of trees per acre as 80, the acreage in both commercial and home orchards was about 3,000 acres. There was a loss of about 50,000 trees in the 10 years

TABLE I. TEN HIGHEST APPLE PRODUCING STATES
(Crop of 1909 according to 1910 census)

STATE	Trees reported April 15, 1910				Products 1909	
	Of bearing age		Not of bearing age		Bushels (Thousands)	Value
	Farms reporting	Number (Thousands)	Farms reporting	Number (Thousands)		
New York	168,667	11,248	48,007	2,829	25,409	13,343
Michigan	153,026	7,534	87,846	2,253	12,332	5,969
Pennsylvania	188,713	8,000	76,841	2,501	11,048	5,558
Missouri	181,396	14,360	75,035	3,625	9,969	4,886
Kentucky	123,037	5,538	68,478	2,106	7,368	3,067
Iowa	148,759	5,847	74,687	1,914	6,747	3,551
California	19,671	2,483	12,716	1,054	6,335	2,902
Virginia	115,881	7,005	61,499	3,436	6,104	3,130
North Carolina...	159,883	4,910	68,268	1,835	4,776	2,015
Ohio	201,044	8,505	77,900	2,438	4,664	2,971

TABLE II. AVERAGE ANNUAL PRODUCTION

(By States, 1899 to 1910)*

		In Barrels	
1. New York	5,122,250	9. Maine	943,666
2. Pennsylvania	3,414,166	10. Iowa	782,416
3. Ohio	2,816,416	11. Arkansas	703,083
4. Michigan	2,608,500	12. New Hampshire	694,500
5. Illinois	1,273,333	13. Mississippi	688,583
6. Missouri	1,130,916	14. Kansas	597,583
7. Indiana	1,088,583	15. Connecticut	518,333
8. California	1,031,418	16. Vermont	502,606

TABLE III. LEADING APPLE PRODUCING COUNTIES IN IOWA
(From the 1910 Census)

Trees reported April 15, 1910

Rank	County	Of bearing age		Not of bearing age		Products 1909		Per cent Iowa crop
		Farms		Farms				
		Reporting	Number	Reporting	Number	Bushels	Value	
State		148,759	5,847,000	74,687	1,914,000	6,747,000	3,551,000	
1.	Mills	1,095	242,466	169	6,032	417,230	204,960	6.18
2.	Pottawattamie	2,751	259,113	778	25,315	375,740	164,197	5.49
3.	Fremont	1,422	155,959	216	6,505	270,690	137,188	4.01
4.	Taylor	1,986	112,585	500	13,416	269,187	125,650	3.98
5.	Page	1,550	113,681	449	11,463	243,724	115,884	3.61
6.	Harrison	1,791	126,295	702	24,288	230,898	101,518	3.42
7.	Ringgold	1,651	76,728	636	15,145	196,531	86,271	2.91
8.	Decatur	1,988	78,269	832	25,530	174,592	84,764	2.58
9.	Appanoose	1,844	79,800	957	31,709	159,896	81,248	2.37
10.	Warren	2,167	114,158	1,005	33,117	149,514	74,907	2.21
11.	Davis	1,894	82,319	917	23,612	148,219	63,142	2.19
12.	Wayne	1,677	58,977	860	23,313	140,413	68,579	2.08
13.	Cass	1,749	83,763	662	15,170	129,318	55,625	1.91
14.	Montgomery	1,418	72,537	365	8,391	119,980	53,925	1.77
15.	Van Buren	1,634	90,527	873	29,038	110,929	55,017	1.64
16.	Madison	1,913	89,771	817	21,304	109,999	54,714	1.63
17.	Monroe	1,260	59,876	488	14,026	108,125	46,494	1.57
18.	Lucas	1,442	56,393	736	20,728	102,640	46,935	1.51

*Statistics from *Better Fruit*, Hood River, Oregon, Oct., 1911.

TABLE IV. NUMBER OF COMMERCIAL ORCHARDS AND AREA
PLANTED IN MILLS COUNTY, 1883 TO 1912

Year planted	No of Orchards	Area, Acres	Year planted	No of Orchards	Area, Acres
1883	1	15	1892	18	269
1884	1	7	1893	17	305
1885	7	120	1894	5	65
1886	2	13	1895	5	65
1887	2	53	1896	6	55
1888	5	80	1897	2	21
1889	4	88	1911	2	13
1890	10	158			
1891	30	620	Total	117	1,947

preceding, making approximately 625 acres less orchards in the county in 1909 than in 1899. Evidently, practically no new orchards are coming into bearing to take the places of those which are being lost. With a total area of 440 square miles, or 281,600 acres, Mills county has an orchard acreage only a little over one per cent of the whole. But Glenwood township shows an orchard acreage of over 1,000, or nearly 10 per cent of its total area.

VARIETIES FOUND IN MILLS COUNTY

While many varieties of apple trees are found in the county, comparatively few are grown commercially. The Jonathan and Ben Davis far outnumber any other varieties. In number of trees planted, Ben Davis probably leads, while Jonathan is a close second.

Each grower was asked to recommend a list of varieties for commercial planting. Table V shows these recommendations. Nearly all name the Jonathan, while some of the other varieties were recommended to be planted with it.

TABLE V. SHOWING VARIETIES RECOMMENDED BY MILLS COUNTY GROWERS

Jonathan	31	Gano	2
Ben Davis	24	Delicious	2
Grimes Golden	14	Willow Twig	1
Duchess of Oldenburg	13	Reynold's Sweet	1
Wealthy	12	Benoni	1
Winesap	4	Black Ben Davis	1
Ralls	4	Missouri Pippin	1
Yellow Transparent	3		

The western Iowa soil grows Jonathan and Grimes Golden to such perfection that it would seem desirable to make these two varieties the leading ones in future plantings. Grimes Golden, however, has one objectionable feature which makes it undersirable to grow on its own roots. In dry seasons the roots evidently do not furnish sufficient moisture, so that the tree is weakened. If these dry seasons are followed by severe winters, the bark will rot away near the surface of the ground, thus killing the tree. Numerous specimens of this variety were found to be in dying condition. Were the tree topworked on a hardier stock like Hibernial or Virginia crab it is believed this trouble would be overcome.

PLANTING PLANS

By far the greater proportion of the Mills county orchards were planted on the square plan as shown in fig. 1. A few were planted on the hexagonal system, fig. 2, and some on the quincunx, fig. 3. Some of the orchards were originally planted as far apart as 36 ft. x 36 ft., but many were planted as close as 16 ft. x 16 ft., 12 ft. x 24 ft., 15 ft. x 30 ft., etc. The average distance for 1,828 acres was 22 ft. x 22 ft., or 87 trees per acre. In all probability the close planting was made with the idea of taking out the trees before they began to crowd, but this has been done in only a few instances. It is rare that a man will cut out fillers and unless he has the courage

to do so, the planting of permanent trees closer than 33 ft. x 33 ft. is objectionable.

Accurate figures as to yield from plantings at these different distances could not be secured, but the health and vigor of the trees was quite noticeably better where the trees were given sufficient space for development.

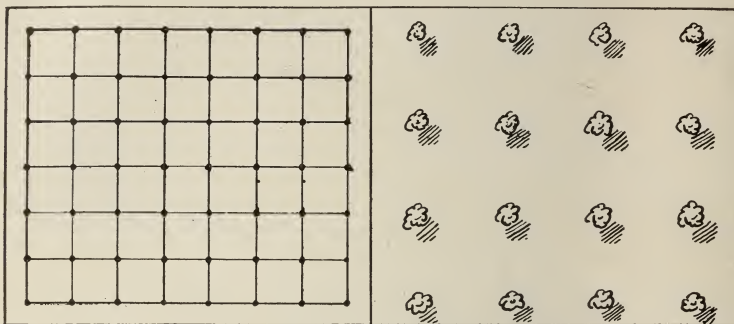


Fig. 1 Rectangular: Original

Properly Thinned.

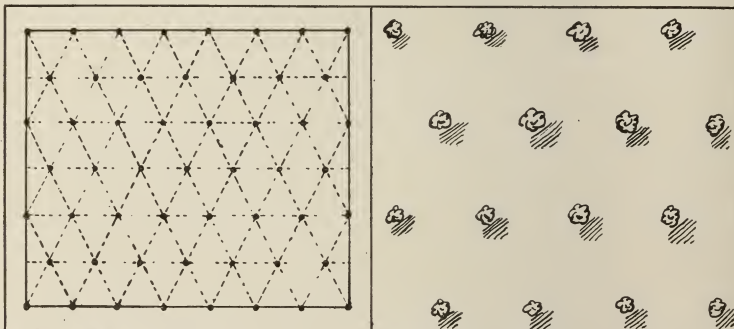


Fig. 2 Hexagonal: Original

Properly Thinned.

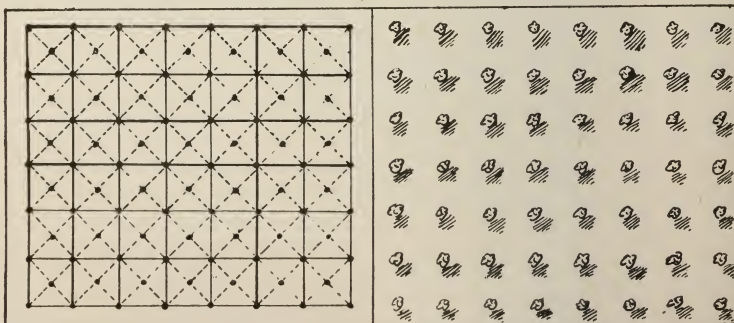


Fig. 3 Quincunx: Original.

Properly Thinned

Trees should not be allowed to crowd and thinning should begin before the branches of neighboring trees interlock.

TABLE VI. YIELD IN BUSHELS, GROSS INCOME AND NET INCOME PER ACRE UNDER DIFFERENT METHODS OF SOIL MANAGEMENT IN MILLS COUNTY

Treatment	No. of Orchards	Yield in Bushels	No. of Orchards	Gross Income	No. of Orchards	Net Income
1909						
Sod	17	165	16	\$ 79.73	4	\$ 60.00
Sod and Manure	4	270	2	100.00	1	166.66
Partial Tillage	2	198	1	50.00	*	*
Partial Tillage and Manure	2	219	1	150.00	1	130.00
Sod Mulch	2	189	2	65.34	2	68.83
1911						
Sod	29	137	21	69.91	15	65.56
Sod and Manure	5	276	3	96.35	4	104.16
Partial Tillage	2	225	*	*	*	*
Partial Tillage and Manure	3	159	3	117.16	2	104.90
Sod Mulch	1	91½	2	37.71	1	34.73

* No reports.

TABLE VII. AVERAGE YIELD IN BUSHELS, GROSS INCOME AND NET INCOME PER ACRE FOR 1909 AND 1911, UNDER DIFFERENT SOIL MANAGEMENT IN MILLS COUNTY

Treatment	No. of Orchards	Yield	No. of Orchards	Gross Income	No. of Orchards	Net Income
Sod	10	162.9	8	\$ 72.68	2	\$ 86.50
Sod and Manure	2	330.75	1	*132.50	2	140.83
Sod Mulch	1	102.75	1	*132.50	1	*115.00
Partial Tillage	2	231.75	1	*132.50	1	*115.00

* Different treatments represented in the same orchard.

TABLE VIII. HOW OFTEN 110 ORCHARD MEN PRUNE THEIR TREES IN MILLS COUNTY

Pruned	No. Orchards	Percentage
Annually	21	19
Not Pruned Annually	89	80.6
Each 2nd year	6	5.4
Each 3rd year	7	6.3
Each 5th year	3	2.7
At indefinite periods	31	28.1
No pruning	42	38.1

TABLE IX. YIELD IN BUSHELS PER ACRE UNDER VARIOUS METHODS OF PRUNING IN MILLS COUNTY

1909			1911		1909 and 1911	
Pruned	No. of Orchards	Yield	No. of Orchards	Yield	No. of Orchards	Average Yield
Annually	8	240	10	233	3	340
Not pruned annually	20	108.9	28	137	11	142.5
Each 2nd year	2	106	3	120	2	75
Each 3rd year	3	131	3	161	2	102
Each 5th year	1	105	2	199		
At indefinite periods ...	5	120	7	129	3	119
No pruning	9	163	13	156	4	169

TABLE X. GROSS INCOME PER ACRE UNDER DIFFERENT METHODS OF PRUNING IN MILLS COUNTY ORCHARDS

1909			1911		1909 and 1911	
Pruned	No. of Orchards	Gross Income	No. of Orchards	Gross Income	No. of Orchards	Average Annual Gross Income
Annually	8	92.55	5	119.20	3	112.40
Not pruned annually	15	70.87	22	64.68	9	66.58
Each 2nd year	2	47.61	2	66.60	2	56.60
Each 3rd year	3	75.83	3	86.53	2	78.65
Each 5th year			1	100.00		
At indefinite periods ...	4	53.60	5	69.04	3	61.25
No pruning	6	87.66	11	53.18	2	72.50

TABLE XI. NET INCOME PER ACRE UNDER DIFFERENT METHODS OF PRUNING IN MILLS COUNTY ORCHARDS

1909			1911		1909 and 1911	
Pruned	No. of Orchards	Net Income	No. of Orchards	Net Income	No. of Orchards	Annual Average Net Income
Annually	3	128.89	6	126.64	3	127.88
Not pruned annually	4	54.16	16	54.91	1	71.00
Each 2nd year			1	69.00		
Each 3rd year			3	40.19		
Each 5th year			1	83.00		
At indefinite periods ...	1	66.66	5	59.28	1	71.00
No pruning	3	50.00	6	51.61		

COST OF PRUNING

The cost of pruning as reported by these growers varied from 3 to 20 cents per tree. Very few had kept accurate figures as to orchard costs, doing the work at seasons when they were not busy at other things and often working only a few hours at a time. The average cost as reported by these growers was approximately 10 cents per tree. One grower in renovating a twenty-year-old orchard gave his cost as 15 to 20 cents per tree. The orchard had not been pruned before for several years. Another grower, in the case of an orchard of about the same age, gave his cost as 10 cents per tree. Those who made annual pruning a practice gave their costs at from 3 to 6 cents per tree. There are many old orchards that would cost 30 to 50 cents per tree to put into profitable bearing.

The growers who had used sprayers were unanimous in agreeing to their value, although one or two who had tried them, had but poor results. Many growers who did not care to go to the trouble of spraying in their own orchards were of the opinion that to make orcharding a success spraying would have to be adopted. Others questioned the value of spraying, and a few objected to the use of poisons in their pastures.

ORCHARD RENOVATION

It matters but little whether there is one tree or several thousand in old orchards. They should be made to pay or be removed and the ground put to other uses. Many farmers have already tired of the unsightly old trees and have removed them. They should be commended for this if they are not going to give them a chance to produce profitable crops.

TABLE XII. GROSS INCOME FROM SPRAYED AND UNSPRAYED ORCHARDS IN MILLS COUNTY IN 1909

	No. of Orchards	Income per Acre
Sprayed	2	\$111.36
Not Sprayed	20	77.89

TABLE XIII. YIELD, GROSS, AND NET INCOME PER ACRE IN SPRAYED AND UNSPRAYED ORCHARDS IN MILLS COUNTY IN 1911

	Yield		Gross Income		Net Income	
	No. of Orchards	Bushels	No. of Orchards	Income	No. of Orchards	Income
Sprayed	4	198	4	\$107.70	4	\$88.77
Not Sprayed	33	172	22	64.10	17	71.24

The most probable reasons for this decline in orchards are a failure to use proper methods of management and a lack of interest in this line of agriculture. The principal agricultural industries in Iowa are grain and stock farming. The orchards were set out at a time when orchard planting was popular, but the trees failed to produce for a few years and the growers became tired of the orchard business. Greater diversification of agriculture is desirable under present conditions and orchards offer opportunity for enlarging the farm income if they are properly handled.

It is not impossible to make orchards bear profitable crops even though they are in a badly run-down condition. Many accounts have been written in recent years of successful orchard renovation, or rejuvenation as it has been called, and some of these read like fiction. In all probability most of them are true, however, for these old trees that have lived and thrived under neglect will well repay all careful work that is put upon them.

The question naturally arises as to what orchards it will pay to renovate. Several considerations must be taken into account before deciding whether it will pay to care for the old, run-down apple orchard.

Of most importance is the attitude of the man who plans to care for the orchard. If he attempts this renovation as an immediate means of increasing his income and does not expect to care for the trees after the initial work is completed, he will undoubtedly fail at it. It will in most instances require two or three years to put the orchard in condition to pay more than expenses, although many orchards have paid profits at once. But the care that follows the thinning out and pruning of the trees is of so much importance that nothing short of a determination to give persistent attention to the old orchard year after year will make it profitable to commence the work. Usually the owner who has not taken care of the trees in the past will not care for them in the future. Therefore, the greatest opportunity is open to the new owners and the younger men who have a liking for fruit growing and will give the trees the attention they need. However, if the present owner can bring himself to believe thoroughly in his orchard and give it the same care and attention that he does stock and grain farming, he can make a profit from the orchard.

WHEN RENOVATION PAYS

If there is a 50 per cent stand of trees in good healthy condition, and if there is a small percentage in addition that can be brought back into bearing by pruning and by the removal of disease, it will pay to undertake the work of orchard renovation. Where thinning is necessary, as is usually the case, the vacancies will tend to reduce

the cost. But if there should be less than 50 per cent of a stand after all thinning is completed, it would pay better to start with a new planting.

WHEN RENOVATION DOES NOT PAY

When trees have been repeatedly defoliated by the canker worms, or by other insects and diseases they lack in vigor and health and it is a question whether they can be successfully invigorated and made profitable. If, however, they are recovering satisfactorily from this loss of leaf surface, then the work may be undertaken with promise of success.

It will not pay to work with trees in the commercial orchard if there is a large mixture of worthless varieties. If the orchard is for home use, a large number of varieties will not be objectionable if they are good ones. If the orchard is for commercial purposes, it will not pay to work with fruit that does not sell readily on the market. Too large a percentage of summer apples is to be avoided unless a good market can be provided. The ideal commercial orchard comprises not more than three or four standard varieties, one summer, one fall, one medium late, and one late winter variety. This is the ideal plan, and the commercial orchardist, whether working with a young orchard or working with an old run-down orchard, should labor to this end. If there are a comparatively few trees of undesirable varieties these may be topworked to standard sorts as suggested in section on topworking.

The location of the orchard will have a bearing upon its possibilities for renewing. If it is far from market, the cost of transportation to the market will be great. The supply of labor should be considered also for the lack of it often means the difference between a large profit and a loss.

A good site for an orchard has good air drainage. Slopes of land that are higher than the surrounding country are desirable. While there is little choice of the exposures, some prefer an eastern slope. In all probability the eastern and northern slopes are cooler, and will retain their moisture longer than the southern and western exposures. It will pay best, therefore, to work with those old orchards that are planted where these conditions can be found. However, unless the orchard is in a "pocket" where frosts are apt to catch the blossoms, it will pay the owner to renovate it, providing the other conditions above mentioned are met.

HOW TO RENOVATE THE OLD ORCHARD

If the orchard is likely to be profitable when renovated, these various steps must be taken in the renovation. First, the trees must be stimulated; second, they must be fed; and third, they must be protected.

In some old orchards the trees are planted far too closely togeth-

er, some not more than 16 feet apart each way. These trees should be systematically thinned properly before any other steps are taken. If the trees are 18 to 25 years old, they should not stand less than 30 feet apart, while a greater distance is better. Where planted as close as 16 feet, three of every four trees should be taken out, leaving the trees 32x32 feet.

Before beginning this thinning out process, the grower should know what varieties are in the orchard. If he does not, he will be unable to tell which he can leave with the most profit. It is therefore best to start renovation in the fall while there are a few apples on the trees so that they can be identified. One of the simplest plans to follow in thinning to proper distance is to plat the orchard on paper, marking the variety of each tree thereon. In determining the vacancies when the thinning is completed the present vacancies should be included when possible. In selecting the trees which are to be left standing, the most profitable varieties should be chosen first, and then those that are most healthy, next.

THINNING

Fig. 4 represents an orchard of 160 trees, 42, or 26 per cent, of which are either missing, weak or undesirable varieties. The dotted lines show one lot of trees that would be left after thinning if the alternate trees on the solid lines were removed. Eight vacancies are found on the dotted lines and 8 weak trees or undesirable varieties, a total of 16, or 20 per cent of the total after thinning. If the trees on the dotted lines were removed and those on the solid lines retained there would be 14 missing trees and 12 weak trees or undesirable varieties, a total of 26, or 32½ per cent of the total after thinning. This diagram illustrates the value of platting the orchard before any thinning is done.

If the original trees stood 16½ feet apart on the plat before thinning they would stand 23.3 feet apart after thinning. If 24x24 feet before thinning they would be 33.9x33.9 after. The latter is a good distance but 23.3x23.3 feet will be found too close after a very few years of proper handling. They can be thinned by again taking out alternate rows leaving the trees 33x33 feet.

If the trees have been crowded, it is sometimes desirable to prune back more heavily from the sides those trees that are to be removed, and leave them standing for one or two years, thus allowing the tree which is to be permanent an opportunity to become accustomed to the greater supply of sunlight gradually. This plan also offers opportunity to secure a partial crop of fruit from the trees that would otherwise be removed. No trees, however, should be allowed to crowd when this method is used and it may be necessary to cut back severely each year. Thinning out of the trees can be done

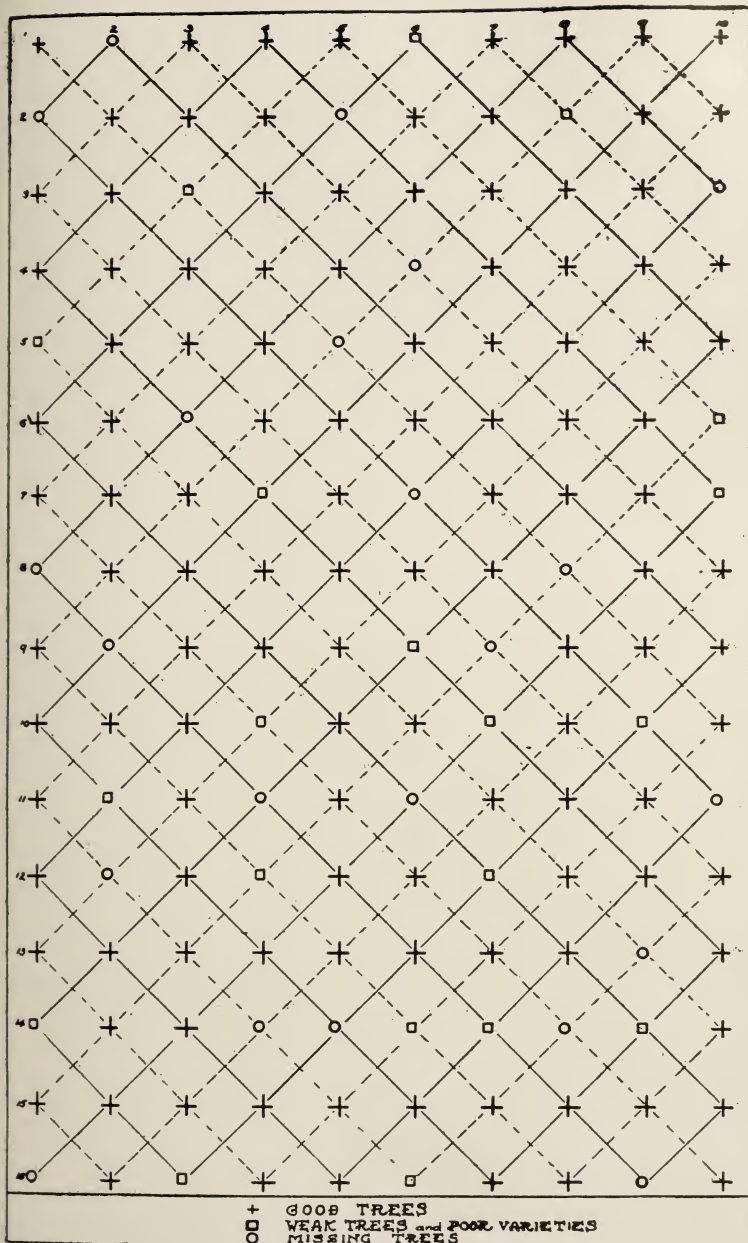


Fig. 4. Plan for thinning an old orchard.

at any time but probably the late winter and early spring offer the best opportunities.

FILLING VACANCIES IN OLD ORCHARDS

Providing there are vacancies in the orchard after the thinning out of undesirable trees, if properly handled it will pay to fill these with young trees. It does not usually pay to attempt to grow an orchard on an old orchard site, but providing the ground is to be worked any way, it will pay to have vacancies filled. To do this most successfully, the tree holes should be dug, or better still, blown out with dynamite, the fall before setting.

With a crowbar or similar instrument make a hole two or three feet deep where the new tree is to be planted. Two feet is deep enough and requires less fuse. At the bottom of this hole insert one-half stick of 40 per cent dynamite, or similar explosive. When this is exploded the ground will be loosened several feet in all directions, if the soil is comparatively dry. When the soil is wet the dynamite compacts it making only a small hole. It is preferable to do this work in the fall and after filling the depression with manure allow the fall and winter rains and snow to leach the plantfood from the manure into the soil and also allow the soil to settle together where crevices have been formed by the explosion. In the spring the manure may be removed and the tree planted. Fresh soil taken from some distance should be filled in around the roots of the young tree. By loosening the soil with dynamite the young trees have a much larger feeding surface. Numerous reports show the successful filling in of vacancies of old orchards by this method. It is claimed that these trees will make a much more rapid growth than those set with a spade. Providing the holes cannot be dug in the fall, it will be advisable to mix well rotted manure with the earth that is filled about the trees.

PRUNING

The next step is the most important operation of orchard renovation—pruning. Any one of several other operations may be omitted, and yet, the work be successful, but if the old trees are not pruned they will not bear satisfactory crops of apples. Pruning should be thoroughly understood before proceeding, but there is nothing difficult about the work if it is given a little attention.

Before discussing the manner of doing the work, the reasons for each operation should be considered. Trees are pruned for several reasons.

First.—To regulate the size and shape of the trees. Such pruning may more properly be called the training of the tree. Many old, neglected orchards have grown so high and have developed so unsymmetrically that the size and shape of the trees need correction. To aid spraying and picking, trees should not be allowed to

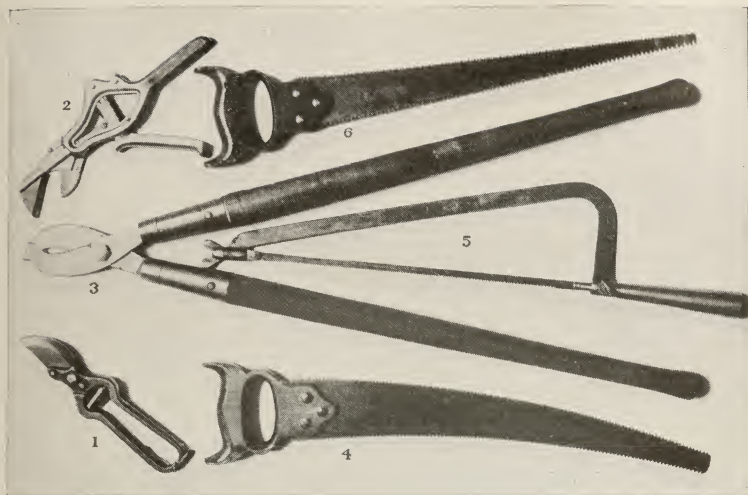


Fig. 5. Pruning tools. 1 and 2. Hand pruning shears. 3. Long handled pruning shears. 4. Curved double edged pruning saw. 5. Swivel pruning saw. 6. Straight double edged pruning saw. Numbers 1, 3 and 5 are recommended.

grow higher than 25 feet. Taller trees should be brought down.

Second.—To remove diseases. Nearly all old orchards contain trees with a large amount of blight, and other cankers. The care of these trees is discussed later.

Third.—To influence the vigor and health of the tree. The removal of a proportionately large portion of a tree takes away wood and leaves that use up plant food or sap furnished by the roots, and makes it necessary for that portion which remains to grow more rapidly to utilize this plant food. In other words, if the demand for plant food is lessened by cutting off some branches the remaining branches have a larger supply to draw upon. The result, if this work is done while the trees are dormant or before growth starts in the spring, will be a much larger wood growth following the pruning. The trees are thus invigorated and strong healthy growth results. Care should be taken not to cause the tree to develop woody growth to such an extent as to decrease fruitfulness.

Pruning during the summer after the active growing season is past usually does not stimulate wood growth but has the opposite effect. Therefore, those trees which are growing too vigorously at the expense of fruitfulness should be pruned just at the end of the active growing season. A good time in Iowa is the last half of June. The trees should be relieved of the immense amount of wood which is a load upon its feeding surface. But the pruning should not be

so severe as to unbalance its activities. It is well to have an ideal tree **in mind** but in these orchards no attempt should be made to cut out **all** that is needed to reach the ideal the first year. The pruning should extend over three, or even four, years.

Fourth.—To regulate fruitfulness. To understand the effect of pruning on the bearing habit of the apple it is necessary to know how the apple tree bears its fruit. The blossoms and resulting fruit are usually borne on the end of short fruiting spurs. Bloom and fruit are frequently borne at the ends of twigs, but this is unusual rather than common. It is needless to say that these spurs, except in very rare instances, should never be removed. Many trees are bare of fruit spurs except at the very ends of the branches. Each fruiting spur usually bears a blossom bud only once in two years. In other words, the fruiting spur which bears fruit in 1914 in all probability will not bear fruit in 1915, but will again produce in 1916. Where a large percentage of the spurs produce in a single season we expect alternately a heavy and light crop. Some varieties, as they grow older, have this habit very markedly fixed, though while young, they may bear moderate crops each year.

PRUNE TO KEEP TREES VIGOROUS

If the trees are pruned just enough to keep them in good health and vigor, approximating as near as may be the condition of the young tree, they can, in a large measure, be prevented from alternating their crops. In other words, all fruit spurs should be kept in a vigorous healthy condition, though not so vigorous as to cause them to grow into long slender twigs. Fruit spurs in densely shaded trees are usually slender and weak. The tree should be opened up sufficiently to allow them to develop normally. Thinning out too many large branches or topping the trees back too severely will often throw these spurs into rapid growth at the expense of fruitfulness. Therefore, the thinning out of just sufficient wood from all parts of the tree, to admit sunlight and air, and the topping back of strong growing branches, sufficiently to give the fruiting spurs a healthy growth will give best results.

How is one to judge the amount of pruning necessary to give the fruiting spurs the right vigor? Generally speaking, weak, slender and dying fruit spurs indicate too little pruning while the development of water sprouts and long twig growth indicate that the pruning has been too heavy. Too heavy pruning, while undesirable because it upsets the normal activities of the tree, may increase bearing wood for subsequent crops.

Heading in, or topping back, tends to increase the number of fruiting spurs, while thinning out all parts of the tree tends to increase the health and vigor of the spurs already borne by the tree. However, heading in, if not too severe, also tends to increase the vigor of the fruit spur.



Fig. 6. Duchess of Oldenberg. Before pruning.



Fig. 7. Same after pruning. The top has been brought down and the surplus wood thinned out.

PRUNING

In pruning an old orchard, these steps may be taken:

First, cut out all "water sprouts" that are not needed to fill vacant spaces. Water sprouts, as a rule, will not bear fruit for several years, but by bending them, cutting them back, or in some other way checking their growth, they can be made to bear the second or third season. These water sprouts may be trained to fill vacant parts of the trees, and when left should be headed back for at least one-third of their length.

Second, remove all cross limbs, i. e., those that cross each other and also those that crowd or rub each other. Remove all dead wood also. After these operations, in all probability, no more wood should be removed the first year. It is important, however, that a sufficient amount of light be given the trees and it may be necessary to open them up more.

Do not remove the fruit spurs along the body of the branches unless they are broken or diseased. This is too common a mistake. Many orchards are so pruned that no fruit spurs are left on the inner under parts of the tree while the outer branches are left so dense that fruit buds will not form.

In the second year it may be well to begin the cutting out of some of the thick heavy heads and the topping back of long slender limbs, either side branches or tops. In all pruning it is better to prune from the top down, rather from the bottom up. Too much wood is apt to be removed from the top of the tree in the latter case and not enough from the top.

DISTRIBUTE THE CUTTING

The cutting should be distributed throughout the top, removing a larger number of smaller branches rather than opening up the top by the removal of a few large limbs. A systematic thinning of the entire top is necessary. With a pair of hand pruning shears clip branches from one inch in diameter or less from all over the outer portion of the tree. It will be necessary to use a ladder for much of this work.

If the tree has developed a tall central leader this should be cut back. From a tree that is 25 to 30 feet high ten feet of the top of the central leader may be profitably removed in order to throw the growth into the side branches. If higher the cutting back will need to be proportionately greater. But if the cutting needs to be severe the top should be brought down gradually, cutting back a few feet each year over a period of three or four years.

Horizontal branches may be cut back also and is desirable where the trees lack vigor.

In topping back the upright branches the cut should be made just above a good healthy, strong, growing, side branch which will serve

as a feeder and prevent a large amount of water sprout growth at the cut and will also heal over the wound earlier. The cut should preferably be made at an angle so that it will shed water better, and also to assist the healing process. To throw long horizontal branches upward, make the cut just above a strong upright growing branch.

The weaker trees should be pruned and cut back the most severely. In some such cases the trees may be shaped up in a single season but with most of the trees the work should be done more gradually to prevent a rapid growing, sappy wood, subject to blight and winter killing, and requiring much subsequent care. Instances are on record where trees have been materially injured or killed by cutting away too much of the top at one time. The vigorous growth and water sprout development may be reduced by removing the dead wood and more brushy part in the winter or spring and then complete the pruning the following June.

In the removal of large limbs that are diseased or undesirable cut parallel with, and as close to, the parent branch as possible. This wound, while larger than a cut perpendicular to the parent branch, will heal much more readily. Stubs such as are shown in fig. 8 offer free access for the entrance of numerous rots. It is sometimes desirable with large limbs to cut them off at some distance from the parent branch to prevent splitting and then remove the stub later.



Fig. 8. Butchering, not pruning. Long stubs admit wood destroying fungi. The lower wound is healing well because cut close. The longer stubs will never heal.

For proper spraying and picking trees should not be more than 20 to 25 feet high. With but few exceptions by careful handling trees can be cut back to that height even though 15 to 20 feet must be removed. It is not desirable, however, to treat the trees any more severely than is necessary, and the removal of a large amount of wood, whether in large branches or in tops, is undesir-

able. Where much wood is removed a rank growth will follow and some trouble from blight may result. This heavy growth must be carefully handled the next season. It is important that these sappy growths be removed the next year to throw strength to the fruiting wood.

WHEN TO PRUNE

The time of the year to prune these old orchards will depend somewhat upon their health and vigor. Trees which have been stunted, or which are not growing as rapidly as they should, had best be pruned before growth starts in the spring. This together with proper soil treatment will produce a healthy wood growth. Wounds naturally heal best when made at a season of the year when growth is most active. Those trees which have been making considerable twig growth at the expense of fruitfulness will pay best if pruned in May or June after growth has started. Winter pruning tends to produce wood growth, while early summer pruning checks wood growth and helps develop fruit buds. Summer pruning will help to decrease the number of water sprouts which follow severe pruning.

But most of these old orchards are low in vitality and need stimulating so that in all but exceptional cases pruning during the dormant season is recommended. This season also offers better opportunity to employ labor at an ordinarily slack time of year.

Heavy freezing and thawing weather following pruning may cause some damage so that where feasible to do so March and April are the better months for this work.

All wounds made in the pruning should be disinfected. For this purpose copper sulphate or blue vitrol solution, formalin solution, corrosive sublimate solution and other preparations are useful. Wounds which are more than an inch in diameter should then be painted with white lead and raw linseed oil, using as small an amount of oil as will make the paint work well. If ten days or two weeks is allowed to pass after the wound is disinfected, the paint will stick better to the dryer surface.

WARNING

Where blister canker, which is described in the following paragraphs is present in the orchard greater care in orchard renovation is necessary. As Ben Davis, Gano, and some other varieties are especially subject to this trouble it will pay to give them special treatment and prune only as much as absolutely necessary for good orchard practice. These varieties should be cut back less severely than is recommended in the foregoing pages and where necessary to lower the tops it should be done by slow degrees. Each and every wound should be carefully watched to see that this trouble does not enter. If it develops the top should be cut back to the next side branch as described before. The pruning tools should be disinfected

after each cut is made. This treatment should be made independent of and in addition to the disinfection of the wounds as given in the last paragraph above. For disinfecting the pruning tools a rag dipped in kerosene may be used. Corrosive sublimate solution may also be used.

BLISTER CANKER

Of the cankers which are prevalent in Iowa, the Illinois, or blister canker is by far the most destructive. Descriptions and treatment for this disease are given by Beach in bulletin No. 127, and by Pammel in Bulletin No. 131, Iowa Agricultural Experiment Station.



Fig. 9. Blister canker on apple in different stages of development.

This disease was found in a limited number of cases in the summer of 1911, but had done a comparatively small amount of damage so far as the utter destruction of the trees was concerned. In the summer of 1912, literally thousands of trees as well as a great many entire orchards were practically destroyed by this trouble in many parts of Iowa. As pointed out in the bulletins referred to, weather conditions, heavy cropping, and other factors prior to the season of 1912 were the contributing causes to the destructiveness of the disease. It was present in the state prior to 1912 but conditions favorable to the spread and destructiveness were not present until 1912.

BLISTER CANKER CONTROL

With very few exceptions, the affected old orchards, composed largely of Ben Davis trees, are beyond recovery. Where the orchard is made up of disease resistant varieties a great deal can be done toward eradicating the disease. In attempting to stamp out the trouble, it will be well first to take out all trees in which the disease has entered the body of the tree, providing it is not localized in a small area. Where possible to do so, it will be much better to remove any cankered limbs, making the cut at some distance below the diseased area as the disease penetrates the wood for some length. After this, the remaining trees which are affected should have all cankers carefully cut out, cutting well back into the live tissue. These wounds should be carefully scraped and treated with some disinfectant like corrosive sublimate, which is best, and then covered with some good covering, white lead and linseed oil being the most easily obtainable.

If the wounds are very large they may be covered with cement. In applying the cement it is best to drive nails closely together part way into the wood so that the cement will adhere to the tree. The cement should be mixed with a comparatively small amount of clean sharp sand, not more than one part of cement and two parts of sand.

One of the best coverings for these wounds is asphaltum paint. An objection to its use is that it needs to be kept above the melting point when applied. A small stove may be carried about to keep the material warm while it is applied. Care should be taken to avoid asphaltum paints which can be applied without heating. These are usually dissolved in kerosene, gasoline or other solvents, all of which are detrimental to the trees. There are several prepared paints on the market which are said to be non-injurious. These have not been thoroughly tested by the experiment station and no recommendations are given at this time.

It has not been determined just how effective the above treatment will be in controlling blister canker. Providing weather conditions are favorable, i. e., an abundance of moisture available, the disease

should be easily controlled, but in very dry seasons when the wood is deficient in moisture it is doubtful whether any methods of treatment will be effective.

One encouraging fact in regard to this diseases is that it is not destructive to Jonathan, Winesap and some of the less important varieties grown in the state.

As blister canker is a wound parasite, that is, it can only enter the tree through a break in the bark, every effort to prevent its entrance should be put forth. Care when pruning to prevent the shoes of the pruner from breaking the bark should be taken. Rubber soled shoes would prevent many wounds which serve as an entrance for the disease.

General sanitary methods should be used about the orchard to cut down the ravages of this trouble.

TILLAGE

If the orchard is in sod and has not been making a satisfactory growth, the sod should be plowed and the ground thoroughly cultivated for a few years. Old orchards covered with blue grass sod are almost as effectually covered to prevent the rainfall entering the soil as though a roof were built over them. Of those grass crops ordinarily grown it is the opinion of agronomists that timothy and blue grass are the hardest upon the soil. Certainly neither is good for an orchard sod.

The best time for plowing is early in the spring as soon as the frost leaves the soil. The ground is usually loose and moist then and plows more easily. Also most of the small root hairs by which the trees take up moisture and plant food from the soil die in the winter and less injury results if the plowing is done before these begin to form in the spring. If the orchard has been in sod for several years it will not be well to plow deeply as too many feeding roots will be destroyed. After cultivation has continued for some time, it can be gradually deepened, thus forcing the roots to greater depth. It will be unnecessary to plow close to the tree in these old orchards as the bulk of the feeding roots are not near the trunk but at some little distance therefrom. The plow should be followed by a disc to cut up the sod. The harrow should be used frequently, at least once each week during the spring and summer; if the soil becomes packed by heavy rains, it should be disced after each rain. All cultivation should cease after the middle of July and some cover crop sown.

COVER CROPS

The cover crop is planted to check growth in the tree so it may properly ripen, thus preventing winter injury, and to catch and hold the snow. It also serves as a protection to the roots in dry, cold winter. The cover crops should be plowed under in the spring be-

fore dry weather comes on and cultivation continued until the middle of July.

In plowing on steep hill-sides that are apt to wash, it will be well to follow the contour and plow around the hill. Good results have been obtained by leaving a strip of sod in the tree row from 6 to 10 feet wide and cultivating in the middle.

Some method of conserving moisture for use by the trees during hot dry summers is imperative and cultivation seems to offer the cheapest way.

SPRAYING

The use of sprays for controlling insects and diseases is accepted by all progressive fruit growing communities as a necessity.

To rid an orchard of its fungus and insect pests, the first spraying should be given just as the blossom buds are separating in the clusters. In this application, it is most important to use some fungicide. Bordeaux mixture is most effectual in the control of scab but lime sulfur will very materially check its growth. For the beginner who is not familiar with the making of bordeaux mixture it will be better to use lime sulfur. The directions for making and diluting both of these liquids are found in Bulletin No. 127 of this station which will be sent free on application.

While the fungicide is being applied at this time, it will not cost any more for labor to apply an insecticide which will help to control all leaf eating insects. Moreover, it is especially important to apply an insecticide at this time to control the canker worm. Three pounds of lead arsenate to 50 gallons of water is recommended for this purpose. Paris green and other arsenicals may be used, but at the present time lead arsenate appears preferable because it is non-injurious to foliage.

The second spraying should be applied immediately following the bloom, or about the time the greater percentage of the blossoms have fallen. The important thing in this application is to lodge the poison in the base of the blossom or calyx. It has been shown by careful counts that three-fourths of the young codling moths enter the apples at the blossom end in the early summer months. By driving the spray into this part of the fruit, these young worms are poisoned before they damage the fruit. In making this second application high pressure, from 150 to 200 pounds is desirable for the most effective control of the worms. Such a pressure, however, can hardly be obtained except by the use of high grade machinery. It seems desirable to apply a fungicide also at the same time the insecticide is applied in this second spraying, and lime sulfur is recommended.

During wet seasons, when apple scab is prevalent, a third spraying should be given about two to three weeks after the second spraying. An application at this time of lead arsenate will hold in check codling moth as well as the green fruit worm and any leaf eating insects.

A fourth spraying, or the third in dry seasons when it is not necessary to apply the spraying just described should be given July 15 to 25, depending upon the development of the codling moth. At this time, or soon after, the second brood appears and the young worms enter the side of the fruit. In case apple blotch has broken out, it would be well to apply bordeaux mixture at the same time. Some benefit may be derived from its application in preventing further spread of apple scab.

SPRAYING MACHINERY

For orchards of ten acres or more, a gasoline power sprayer is highly desirable. These can be purchased at from \$150.00 to \$300.00. For from five to ten acres of orchard, it is barely possible that a horizontal double action pump fitted to a tank will be most economical. Where the orchard is small, ranging from 50 to 300 or 400 trees, a good barrel outfit will suffice. The double action pump can be purchased at from \$35.00 to \$65.00 each; the barrel pumps at from \$10.00 to \$40.00 each.

There are many hillside orchards in Mills county in which it would be difficult to spray with an ordinary gasoline power outfit because of the danger of tipping over. Several companies, however, are manufacturing spraying machines with the tanks hung low so that this danger is practically eliminated.

To do effective work in spraying several small appliances should be included in ordering a spraying machine. Good hose, guaranteed to withstand high pressure, is necessary. At the end of each lead of hose a good cut-off should be provided. A bamboo spray rod from 8 to 12 feet long is necessary for the best work among tall trees. At the end of this spray rod should be provided either an angle connection or an angle nozzle. Where power sprayers are used, a "Y" or "U" should be provided so that two nozzles may be attached. This greatly facilitates the work. For the first, third and fourth sprays a nozzle which throws a fine mist is desirable. For the second spraying, a nozzle which will throw a driving spray is best. In this case it is desirable to throw the mixture with considerable force in larger drops so that it may penetrate the blossoms, while in the other sprays it is desired only to cover the surface of the fruit and foliage. Among older orchards a tower will be found indispensable if thorough work is to be done. This tower need not be more than 8 feet high from the ground to the platform.

TOP WORKING

In many of Mills county orchards twenty to thirty years old are trees of undesirable varieties, either little known sorts of early varieties which are not easily marketed. Many of these trees might be made to pay a profit by top working them to more desirable varieties. In some cases Russian varieties are extensively found. As a rule these prove hardy and vigorous but are not good commer-

cial sorts on account of early ripening. However they do make excellent stocks upon which to work later ripening standard varieties. Because of the heavy demand for nursery stock in the late 80's and early 90's when the older orchards were planted, many mixtures of varieties occurred. These odd varieties are objectionable as they ripen at different seasons and necessitate much travel from tree to tree to avoid mixing fruit at harvest time. Where this is true, it will also often pay to change these varieties to those desired whether in the commercial or home orchard.

Top working is not difficult if the essential factors are understood and simple directions followed.

Grafting is employed to propagate a tree or plant that bears superior fruit or flowers or foliage. It does not improve the varieties propagated, except as it may increase size or production. It simply perpetuates the characteristics of the individual tree or plant from which the cions are cut.

The cion is the cutting from the tree to be propagated which is inserted into the stock upon which it is desired to grow a new top. The cion is usually about six inches long and should be taken from the previous season's growth, as older wood is less suitable for grafting. The cion should have well ripened wood and well developed buds.

Trees to be used for stocks should be in good health and vigor. It is useless to try to graft trees that are low in vitality. The union between stock and cion should take place soon after the top working is done and the wounds should heal rapidly. These requirements can only be secured in healthy vigorous trees.

The cions should be dormant when inserted in the stock. They may be cut and stored before hand if desirable. Pack in damp moss and store in a cool cellar or bury them a foot or two below the surface of the ground and they can be kept indefinitely. If too wet, they are apt to mold. If too dry, they will not grow. They should be protected against freezing because freezing is a drying process. Cions may be shipped long distances if these requirements are observed.

Grafting can most conveniently be done, as a rule, just before growth starts in the spring. The wounds will heal most rapidly if the cuts are made at that time. However, the work may be done after several inches of growth has taken place if the cions are kept dormant.

The union, upon which success depends, takes place at first between the cambium layers of the stock and cion. These must be brought in close contact and held there. The cambium layer is the active growing part of the tree and is situated just between the bark and wood. Where the bark of the stock is thicker than the



Fig. 10. A McIntosh Red apple tree before top working.



Fig. 11. Same tree after top working, showing about the proper amount and distribution of work to be done the first season.

bark of the cion, it is necessary to set the cion back from the outside surface of the stock to bring the cambium layers together.

The cut surfaces should be protected from air and rain. Air evaporates the sap of the tree and also may carry disease. Rain helps to furnish conditions favorable to the development of rot.

Health, vigor, close contact of cambium and protection are the only essentials for success. Any workman can by careful work make a large percentage of grafts grow.

A saw will be necessary to cut off large limbs. One like that shown in fig. 12, is preferable. Smaller branches may be cut with a small pair of hand pruning shears or a knife. A grafting chisel like the one shown in fig. 13 is very handy and it will pay to secure one if a large amount of grafting is to be done. The cleft to be described later may be made with a saw, though it will not be as smooth, making it more difficult to secure close contact of the cambium layers. In addition to the chisel referred to, a mallet or short club will be needed to split the stock. Grafting wax is required for covering the wounds.

There are several ways of making and applying the wax. The preferable method is to keep the wax warm and apply it with a brush. In this method melt together 6 parts of rosin, 1 part of beeswax and 1 part linseed oil. This may be kept warm in the orchard by means of a small stove in a sheet iron cylinder which can be carried through the orchards. However, the wax will remain soft for some length of time. Care should be used not to apply the

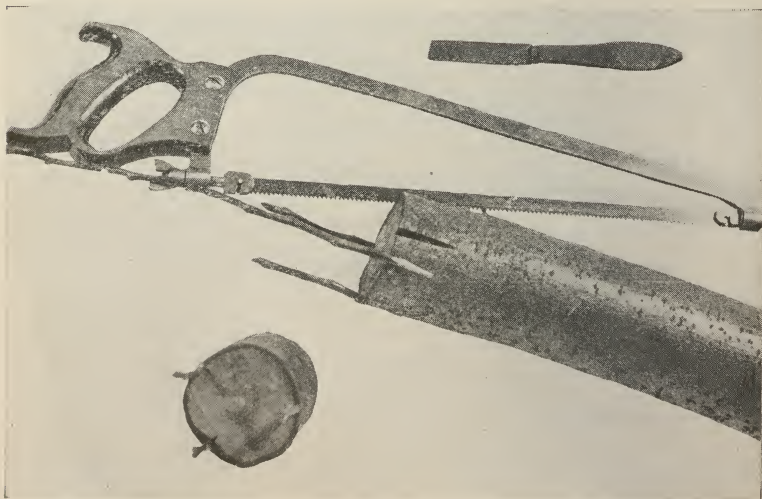


Fig. 12. Details of cleft grafting.

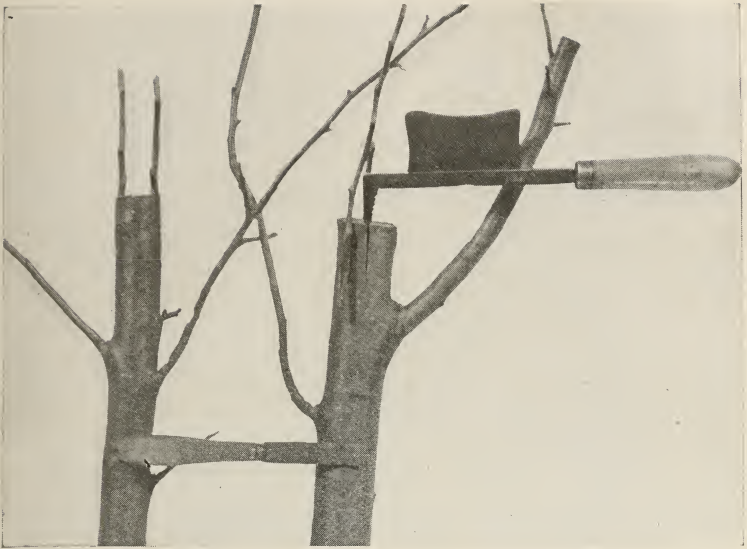


Fig. 13. Details of kerf grafting or inlaying.

wax too hot as injury to the bark would result. This is not apt to occur with moderate precaution.

A soft wax may be made and applied by hand. Melt together one part of tallow or linseed oil, two parts of beeswax and four parts of rosin. After cooling, pull like taffy and wrap in oiled paper until used. Tallow or other grease should be applied to the hands when using this wax.

Waxed cloth may be made by soaking muslin in the wax while hot.

From three to five years should be taken to work over an old tree entirely. Only a small number of branches should be worked each year. These should be distributed well over the tree, always taking care to leave branches to protect the young cions against the sun, and to furnish foliage to keep the tree in a healthful condition of growth. Select the most vigorous branches first. These will usually be found in the center of the tree. The weaker branches will not furnish sufficient sap and the more strongly growing ones will rob them.

If it can be avoided, it is not desirable to graft branches more than $2\frac{1}{2}$ inches in diameter, but larger branches may be used successfully with careful work. Figs. 10 and 11 will illustrate about the amount and the distribution of grafting to be done the first year. The original form and symmetry of the tree should be maintained so far as possible.



Fig. 14. Kerf graft on top worked tree properly waxed and wrapped with cloth to protect the wax from the sun.

The stubs should not, as a rule, be more than six to twelve inches long. The smaller outer ones are cut closer than the larger ones near the base or head of the tree. The larger branches need shade and side branches should not be pruned away to expose them. The grafts should be distributed throughout the tree.

In completing the work the third or fourth year, more branches should be grafted than will be finally needed. These can be cut out later after the new head is well formed.

When removing larger limbs for grafting it is well to make the cut at some distance from where the cion is to be placed to prevent splitting. This stub is then cut to the desired length.

For larger branches the cleft graft is commonly used. The spring of the wood holds the cion firmly in place. A cleft is made with the grafting chisel, taking care to get a smooth cut and then a cion cut to fit is inserted. On horizontal limbs the split is made so that one cion does not come above another.

The cion is usually about six inches long though one as short as three inches may be used. It should have a bud near the top or smaller end and one at the butt at the point where it leaves the stock. The butt end of the cion should be cut to a long, smooth wedge shape. One edge of the wedge should be a little thicker than the other so that when it is inserted in the split of the stock with the thick edge outward, the fit will be closest there.

The split is wedged open with the point of the chisel and the cions carefully placed one on each side of the larger branches. Care should be used here to see that the inside of the bark of both cion and stock come in close contact. This may be accomplished by setting the cions at a slight angle. The chisel is removed and all cut surfaces, including the tips of the cions, covered with wax. The wax about the stub should then be wrapped with cloth to protect it from melting in the hot sun of summer and exposing the cut surfaces to the air.

In larger branches, several cions may be set by sawing a long, shallow, trough shaped cut through the bark and carefully trimming it with a sharp knife and cutting the cions to fit. This increases the chances of one cion growing. See figs. 12 and 13.

In either case, if more than one cion grows, all but one should be removed after one or two years, retaining the strongest or most desirably placed.

After the grafting is done, the trees will demand careful attention. The removal of so much wood will cause a large growth of water sprouts which are apt to rob them of sap. Some of these should be removed and the others cut back in June and probably once or twice later in the season. The branches and stubs should be shaded, but too much growth will smother out the young cion growth. If the cions make too long and slender a growth, it may be well to pinch them back, forcing them to make a more stocky growth.

The whole process is a shock to the tree and it will need care to revive as quickly as possible.

While this work would be expensive if undertaken on a large scale, a few trees can be worked in a comparatively short time and as the topworked tree will bear fruit in from three to five years after the cions are set, the results are sufficiently prompt to make it more desirable in many cases than to remove the old tree and plant a new one.

CONCLUSIONS

Apple orchards can be made to pay a profit in most localities in Iowa. The principal factor lacking at present is the men who are willing to make orcharding a business venture and to give it the attention that they would do any business that they expected to make a success.

It was a common theory among the farmers, as well as among fruit growers and others, that the climate of Mills county was not adapted to the growing of fruit. Late spring frost was the principle factor cited as a reason for this belief. Nevertheless it is a well known fact that the danger of late spring frosts and freezes which damage the fruit crops diminishes from south to north, the reason being that the plants bloom later the farther north we go and are therefore held back till after the danger of frost is past. Iowa can grow late winter apples over a large portion of the state and the nearer the northern limit of late winter apple production we go

the less danger there is of late frost injury. During the past six years Iowa has had but one serious loss from damage to fruit by late spring frosts and freezes. Apple orchards may be protected against frost by the use of orchard heaters but this means a protection is recommended only to those who by the adoption of methods of culture have brought their orchards up to their maximum production. Unsprayed, unpruned, and otherwise neglected orchards will not pay for this protection.

The results secured by the use of manures in Mills county orchards are indicative of the necessity of giving more attention to the plant food in the orchard soil. Manures if they can be secured at a reasonable price are the best fertilizers for orchard use.

The results of pruning and spraying in Mills county orchards as shown in the tables in the fore part of this bulletin are also indicative of the value of these two important orchard operations. Neither can be entirely neglected and success be assured. Spraying is absolutely essential in the growing of marketable fruit.

Apple orchards where well cared for have paid, and are paying excellent profits on the money invested. They produced profitable crops with less care in the early history of the state. At that time there were few if any destructive insects and diseases to lower the profits of the grower. Large plantings were made between 1880 and 1900 as a result of these easy profits. These came into bearing after the introduction of the pests referred to and those men who did not care to properly protect their trees against the pests and against drought found that their orchards were not profitable. This has been the history of practically all the older fruit growing regions and was the expected result.

The question of over-production of apples is often discussed by fruit growers in the state and various opinions are held. There is but little doubt that the home market will consume a large part of the fruit grown in the state if that market is developed by proper methods of grading and advertising. The markets of the country at large will be open to properly grown fruit from Iowa as there is no question but that such fruit when properly packed and advertised will successfully compete with that of any region. The greatest difficulty in the marketing of the fruit will be that not enough fruit will be produced to attract the larger buyers to the local community. By organization of the growers and a careful study of the markets this difficulty can be overcome.

The toll of destructive insects and diseases has been pointed out. These pests will in reality prove a blessing in disguise to the man who will properly care for his fruit. By rendering what little fruit the neglected orchard will produce, unfit for market, they will leave the market entirely open to the better fruit produced by the careful orchardist. Such conditions are to the advantage of the man who will care for the old run-down orchard and plant new trees to replace the old when they have passed the age of profitable production.

For the men who do not care to make orcharding a prominent part of their business on the farm it will be better to remove all but a few trees for the home supply and put the remainder of the ground now in orchard to some crop that will be properly cared for. But a careful consideration of the foregoing pages and the profits to be derived from the orchard crops, is urged before the decision to remove the orchard is reached.

CORN STALK AND CORN ROOT DISEASES IN IOWA

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IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

BOTANICAL SECTION



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CORN STALK AND CORN ROOT DISEASES IN IOWA

By L. H. Pammel, Charlotte M. King and J. L. Seal.

Although it has been generally believed that corn is less subject to the attacks of fungus than any other agricultural crop, it is estimated that corn smut, corn rust and bacterial disease damage the crops in Iowa to the extent of \$8,000,000 annually. In 1914 the attention of the Botanical section of the Iowa Agricultural Experiment Station was called to a new and important disease attacking corn which was later found to be wide spread in the state, working great damage.

It is important that vigorous steps be taken against corn diseases, for the largest farm crop in the state of Iowa is corn. In the year 1914, in spite of the drouth, serious fungus disease, and other enemies, the yield of corn as given by the United States Department of Agriculture was 389,424,000 bushels. At present prices that crop is valued at \$194,712,000.

Corn has been generally considered less subject to attacks of fungus disease because there have been no wide spread epidemics as with wheat, where rust sometimes destroys more than 50 per cent of the crop. However, such fungus diseases as corn smut, bacterial diseases of corn and corn rust are well known and have long done some damage. That damage is not as great as that inflicted by oat smut which has been estimated to decrease the yield of oats very materially causing a money loss to the farmers of Iowa of about \$7,000,000 annually. Oat rust causes about an equal damage, making a total loss on the oat crop of about \$14,000,000 annually. Corn smut, corn rust and the bacterial disease damage the corn crops of Iowa to the extent of \$8,000,000.

NEW AND IMPORTANT DISEASE OF CORN IN IOWA

The attention of the Botanical section of the experiment station was called to the new and serious disease of corn, early in the fall of 1914 by Prof. H. D. Hughes. He found it on one of the experimental plots of the college farm. Subsequent investigation indicated that this disease was wide spread in the state. This disease was characterized by falling of the corn or the stalks were broken close to the joints. Such plants contained only small ears or they were barren. When a farmer's attention was called to this condition the statement was usually made that the stalks were blown over by the wind or that the trouble was caused by the corn root louse or corn root worm.

A personal field study of the disease was made in the following counties: Story, Boone, Carroll, Harrison, Pottawattamie, Monona, Woodbury, Polk, Lee, Appanoose, Monroe, Davis, Van Buren, Marshall and Clay. Inquiries were sent out to a large number of correspondents, requesting information in regard to the disease. The letters and diseased specimens received show that the disease occurred near the following places: Corydon, Gilman, Nora Springs, Mt. Pleasant, Mt. Ayr, Indianola, Dallas Center, Sanborn, Estherville, Amana, Leon, Maquoketa, Keystone, Armstrong, Clinton, Creston, Peterson, St. Ansgar, Atlantic, Bloomfield, Waukon, Sutherland, Washington, Earlham, Sioux City, Whiting, Council Bluffs and Spencer. This indicates a wide distribution in the state.

YIELD OF CORN IN DISEASED FIELDS

From the figures obtained it appears that the yield in infected fields was reduced from 10 to 15 bushels per acre, or frequently from 25 to 30 per cent.

To illustrate, in some fields 10 stalks out of 22 were attacked; in one field, 23 out of 26 were attacked. In an upland field of corn, said to be fairly good, 41 per cent of the plants were attacked, and the yield was a little over one half of a crop. In many other fields in this vicinity the loss was fully one-third of the crop. In addition, many ears of corn were attacked by a similar mould. The loss from ear rots in Illinois estimated by Burrill and Barrett* was placed at about \$5,620,147 in 1906 and \$2,000,000 in 1907.

The ear rots of corn in Iowa this year probably damaged corn to the extent of \$5,000,000. Considering the loss due to the corn stalk disease these two diseases at a conservative estimate cost Iowa in the neighborhood of \$15,000,000. In many cases badly diseased fields of corn yielded only 10 to 15 bushels of corn per acre. This is certainly a question of considerable economic importance to the farmers of Iowa.

CHARACTER OF THE DISEASE

This disease attacks the roots, the stalks and the ears. It has not been determined whether all these diseases are caused by the same organism or not. The Illinois authorities described four organisms on the ear.

Root Diseases.

During the early part of September in many parts of the state corn was lying on the ground. This was attributed to a severe windstorm. It was, however, soon found that such corn was invariably attacked by a fungus, which had killed the

*Burrill, Thomas J. and Barrett, James F., Ear Rots of Corn, Bull. Ill. Agr. Exp. Sta. 133:69.



Corn field showing results of a fungus attack; many stalks broken near the lower nodes, others prostrate on account of diseased roots.
— (Photograph by Colburn)

roots of the plant. Such roots were always colored reddish and the attacked plants could be pulled easily from the ground. Such roots were completely destroyed.

The Disease on Corn Stalks.

In many fields the corn was broken off just below the joint or above. The pith or soft material in the corn stalk was destroyed, brownish or in some cases reddish in color. The fibers were soft and easily broken off. Such stalks were barren or had only small ears. The small dwarf shoots in the axils of the leaves were frequently decomposed. On the surface of the stalk and in the nodes there was an abundance of the mould*

Ear Rots.

Nearly every farmer has observed an occasional ear attacked by a mould.** These moulds are of three kinds. One attacks the kernels, husks, cobs and sheaths, the threads of the mould occurring through the cobs and sheaths of corn and destroying the kernels completely. This fungus occasionally produces a pinkish color. The second produces a deep pink or red color, the threads of this fungus are felty, and they penetrate the husks, and the kernel becomes brittle and red. The third type attacks an occasional kernel. It is not so serious. Its threads are white.

Diplodia Rot.

A third fungus*** was found on the ears, stems and sheaths, this fungus also occurs on the roots. It is not, however, the cause of the falling of corn.

HOW THE FUNGUS SPREADS

The fungus spreads from the mould on the kernels or from the diseased stalks left in the field.

The disease may have existed in Iowa for some years. The ear rots of corn have long been observed by the Iowa station. A brief note by Selby† of Ohio describes the disease in that state and it was described by the senior author of this circular in the Iowa Agriculturist.††

THE CORN STALK DISEASE IN CATTLE

Numerous complaints have come to us in regard to a disease in cattle which goes under the name of corn stalk disease, or forage poisoning. It was so severe in some parts of the west this past year that some veterinarians have advised farmers

*This was determined as a species of *Fusarium*. Other species of this genus cause wheat scab or blight, flax wilt, cucumber wilt, etc.

**Described by Burrill and Barrett, Bull. Ill. Agrl. Exp. Sta. 133.

***Bull. Ill. Agrl. Exp. Sta. 133:94-96. Nebr. Agrl. Exp. Sta. 1909:1-20.

†Selby, A. D. Brief Handbook of Plant Diseases Bull. O. Agr. Exp. Sta. 214.

††Vol. 15:153-158 2 f. Nov. 1914.



Stalks of corn weakened by fungus, broken below or above the node.
—(Photograph by Colburn)

not to feed corn stalks. While it is not known that this fungus is connected with this disease in cattle, due to feeding on mouldy corn and fodder, there are good grounds for believing that these moulds are toxic.

Experiments are now being conducted to determine some of these points.

TREATMENT

The only rational treatment is rotation of crops. Corn should never follow corn where this disease exists, since the fungus remains on parts of the plants attacked when corn is planted in the same field the next year. Young plants will become infected. It is a wise plan to treat corn with formalin at the rate of one pint to forty-five gallons of water for fifteen minutes. This will destroy all of the spores adhering to the surface of the corn.

Experiments are under way at the Iowa Station to determine how the fungus grows and under what conditions it attacks the plant.

IOWA AGRICULTURAL EXPERIMENT STATION

ENTOMOLOGICAL SECTION

THE HESSIAN FLY *

By R. L. Webster.

In 1914 occurred the most severe outbreak of this dangerous pest Iowa has ever experienced. It was found over a large portion of the southern half of the state, although worst in southwestern Iowa. The accompanying map shows where the reports came from. Many counties not indicated on the map certainly have the insect, though it was not reported to the Agricultural Experiment Station at Ames.

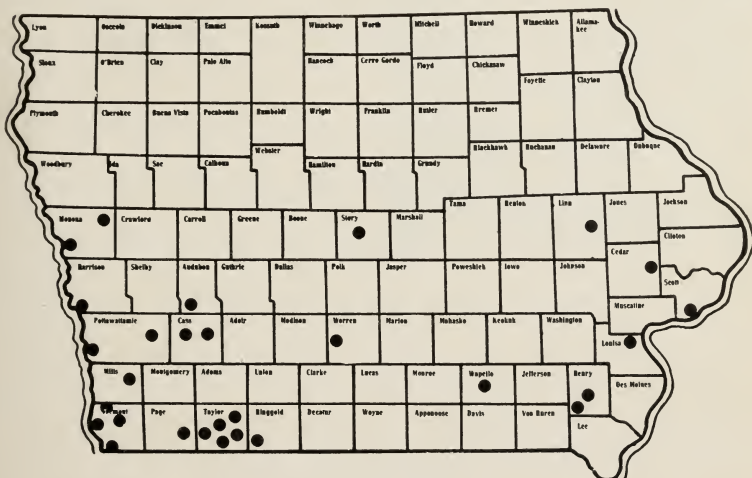


Fig. 1. Hessian fly reports in 1914.

Iowa farmers are not so well acquainted with this pest as those of states to the east. In Ohio the Hessian fly became so serious that in 1900 the average wheat production for the state was less than 5 bushels an acre; a loss amounting to more than \$15,000,000.

NATURE OF THE INJURY

The damage to wheat is caused by the maggots of the Hessian fly. The fly itself, that is, the adult insect, does not feed on the plant.

These maggots, or larvae as they are called, are found within the sheath of the wheat plant. In the fall they feed close to the roots, where they may be discovered easily by pulling down the blades. They do not enter the stem itself. Often these maggots are abundant on plants, 15 or 20 or even more on a single plant. After

**Mayetiola destructor* Say.

wheat joints larvae may be found above the joints, still within the sheath.



Enlarged. From Pettit.

Fig. 2. Flaxseeds in young wheat. pale white in color, with rather a flaky appearance, measuring about 1-5 inch long. These larvae assume the brown "flaxseed" stage, the stage in which the insect is usually found and in which it spends the greater part of the year.

The flies are small midge-like insects, 1-10 inch long, dull and inconspicuous in appearance.

These, then, are the four stages of the insect; the egg, the maggot or larva, the flaxseed or puparium and the adult fly.

FOOD PLANTS

Of the small grains, wheat, rye and barley are infested. Rye is injured less than wheat, and barley least of all three. Flaxseeds of the Hessian fly have been found on the stems of certain wild grasses, but never to any great extent. So it appears that there is little danger of infestation from this source.

SEASONAL HISTORY

Wintering in the flaxseed stage on wheat plants, the insect emerges as the adult fly sometime in late April or early May. These flies deposit their eggs and young larvae hatch in a few days time. So by the middle of May, in Iowa, the first brood of larvae is in abundance on wheat plants. In late May these larvae mature and transform to the flaxseed stage, during which the insect does not feed.

Wheat plants are affected both directly and indirectly. They are directly affected because the maggots frequently take so much nutriment from plants that these die. Again plants are so weakened by the presence of maggots that less grain is produced. The wheat yield is indirectly affected because weakened plants bend or break at the joints at harvest, causing them to fall. Lodging of wheat always accompanies injury by the Hessian fly.

THE STAGES OF THE INSECT

The eggs of the Hessian fly (see fig. 3) are deposited on the blades of the plant. Eggs hatch in from 4 to 10 days and the larvae work their way down the plant within the sheath. These eggs are very small, only about 1-50 inch long, slightly reddish in color. In fact, they would be usually overlooked, even when abundant on a blade.

Full grown maggots are

Usually these flaxseeds go on through the summer until fall, on the wheat stubble, before the flies emerge. But some adults may emerge from the flaxseeds and these will deposit eggs and form a partial brood of larvae. In general, however, the summer is spent in the flaxseed stage on wheat stubble. Now in the fall, in September, adult flies emerge from the flaxseeds in great abundance. The earlier ones deposit eggs on volunteer wheat or on the earliest fall sown wheat. The larvae from these eggs go on through their transformations, feed on young wheat in the fall, mature and form the flaxseeds. Sometimes, when exceptionally mild weather occurs in the fall, another partial brood of larvae may be produced. Such was the case in Kansas in 1914.

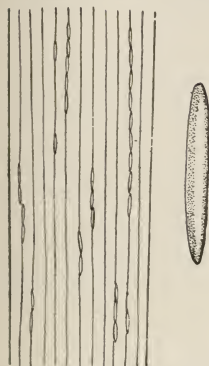


Fig. 3. Egg of the Hessian fly, greatly enlarged; section of leaf of wheat, at right, showing eggs as usually deposited, less enlarged. (From F. M. Webster, U. S. Dept. Agr. Bur. Ent.)

CONTROL MEASURES

In the Spring. The spring is not particularly a good time to take any measures against the fly. However, much may be done, for any volunteer wheat or wheat stubble, never plowed under, is likely to contain flaxseeds. Any of this remaining in spring should be plowed under as early as possible, thus burying the flaxseeds. The flies emerge early, so any plowing must be done early to be of any value.

Sometimes sown wheat is so badly infested that it will not pay to let it stand. In such cases it is best to plow this under, thus burying all the insects, so they cannot emerge and infest other wheat. This may be done early enough so the land may be put in corn.

In the Summer. After harvest is the best time to take measures against the Hessian fly. All summer is spent in the flaxseed stage on wheat stubble, where the insect can usually be reached.

Stubble may be burned over soon after harvest. This destroys a large percentage of the insects. There are, however, some undesirable features about this measure.

It does not get all the flaxseeds, since some are on the plants below the soil. Again, wheat stubble should be turned back to the soil, on account of its value as plant food.

Fig. 4. Larva of Hessian fly before "flaxseed" is formed. Much enlarged. (From F. M. Webster, U. S. Dept. Agr. Bur. Ent.)



Fig. 5. Puparium or "flaxseed" of Hessian fly. Much enlarged. (From F. M. Webster, U. S. Dept. Agr. Bur. Ent.)

In Kansas, according to Messrs. Headlee and Parker, plowing wheat stubble under was found a more efficient measure than burning it over. To be effective, all stubble must be well buried, and volunteer wheat must not be allowed to grow up afterwards.

Infested wheat stubble should be disked immediately after harvest. This makes plowing easier and conserves moisture. Then, 3 or 4 weeks later, the field should be plowed under, at a depth of 6 inches, completely, burying all stubble. Later, by harrowing, all volunteer wheat should be destroyed, for stray flies will breed in this and go to sown wheat later on. With such a treatment, provided it is well done,

wheat may follow wheat with a minimum chance of danger from the fly, but the wheat should not be sown early. The time of sowing is discussed later.

Clover and even alfalfa frequently are sown in wheat, making difficult such measures as burning stubble or plowing it under. When the Hessian fly is abundant in any locality this practice should be cut down to the minimum, for it encourages the insect in every way. There being nothing to prevent, the flies emerge from wheat stubble in the clover field and go to the nearest wheat. If infested wheat stubble is not disposed of in some way, then fall wheat should be seeded just as far away from this as possible.

In the Fall. By sowing wheat as late as possible, and yet obtain a good stand, much benefit may be obtained, although there is danger of winter killing if sowed too late. The idea in late sowing is that the wheat may come up at a time in the fall when most of the flies have disappeared.

Late sowing benefits only so far as the fall generation of the insect is concerned. All wheat is liable to infestation in the spring, so that late sown wheat is open to injury then as well as that sown early. But if late sown wheat escapes damage in the fall, the chances for injury are greatly reduced in the spring, since the majority of the flies will deposit eggs in the field where they emerge.

Some 15 years ago in Ohio F. M. Webster gave approximately safe dates at which fall wheat may be seeded and escape severe injury by the Hessian fly. More recently Headlee and Parker gave similar dates for the wheat growing section of Kansas. From the Kansas dates and also from observations by the writer in southwestern Iowa, it appears that wheat sown in October 1, in the southern tier of counties, should escape the fall brood of the fly. For central Iowa this date would be about September 25.



Fig. 6. The Hessian fly; adult male, much enlarged. (From Marlatt, U. S. Dept. Agr. Bur. Ent.)

COMMON CORN INSECTS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

ENTOMOLOGICAL SECTION



Ames, Iowa

COMMON CORN INSECTS

By R. L. WEBSTER

WIREWORMS*

The Injury. Injury to corn by wireworms occurs in spring soon after planting. The failure of seed to sprout, or the dying or withering down of corn plants about two feet or less in height, both indicate wireworm attack. If the field so affected has been in grass a year or so previous, the injury is most likely to be that of wireworms. Although the larvae do not cause any visible injury to grass, when such land is put into corn the wireworms concentrate upon the hills of the planted grain, causing much damage.

Wireworms feed first on the seed itself, later on the roots, eating entirely the smaller ones and boring or penetrating the larger ones.

The Insects. The common corn wireworms are reddish-brown in color, hard and rather shiny in appearance, cylindrical in shape, an inch or more in length. Several species of the genus *Melanotus*, as well as the common wheat wireworm, *Agriotes mancus* Say, attack corn. (Fig. 1.)

Larvae of *Melanotus* may spend as long a time as 5 years in the soil. The life history of the common species is not yet well worked out but it is evident, from recent studies by J. A. Hyslop, that so long a time as this is possible with its larvae. One of the corn wireworms of this kind is shown in fig. 2. The adult beetles are boat-shaped fellows, $\frac{1}{2}$ to $\frac{3}{4}$ inch long, and usually brownish in color. They are known as "click-beetles," or "snapping beetles," from the snapping noise they make when held in the fingers or when turned on their backs.

The wheat wireworms spend 3 years in the soil, less time, on the whole, than wireworms of the genus *Melanotus*. The adults of this species are small, brown beetles a little more than $\frac{1}{4}$ inch long, stout and somewhat hairy.

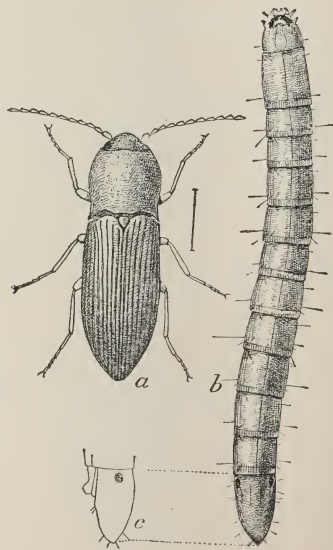


Fig. 1—The wheat wireworm (*Agriotes mancus*): a, adult beetle; b, larva; c, side view of last segment of larva. All enlarged. From Chittenden, U. S. Dept. Agr.

**Agriotes mancus* Say.
Melanotus spp.

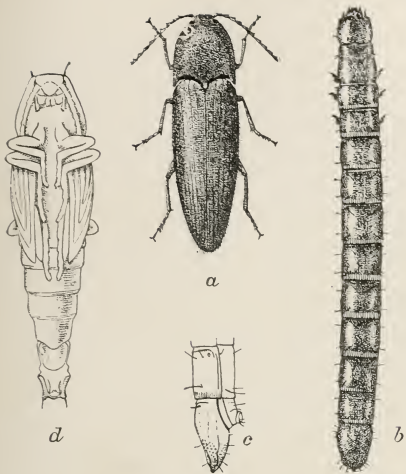


Fig. 2—One of the corn wireworms (*Melanotus Communis*); a, adult beetle; b, larva; c, the last segments of same; d, pupa. All enlarged. From Chittenden. U. S. Dept. of Agr.

Before changing to the adult "click-beetle," the wireworm in July and early August of the year it becomes mature, first changes to the intermediate pupa stage (fig. 2). Only two or three weeks are spent in this stage before changing to the beetle, but the beetle does not emerge at once. Instead, it spends the winter in the pupal cell, emerging the next spring and then depositing eggs from which to hatch more wireworms.

Control Measures. Wireworms are extremely difficult to control because inaccessible for practically all their life. J. A. Hyslop makes the following recommendations for wireworms infesting corn in a recent bulletin of the U. S. Department of Agriculture.

Regarding first infestation by wheat wireworms:

"We recommend plowing sod land immediately after the first hay cutting, usually early in July, when the land is intended for corn the following year. This land should be cultivated deeply throughout the remainder of the summer. Land that is in corn and badly infested should be deeply cultivated even at the risk of slightly 'root-pruning' the corn. This cultivation should be continued as long as the corn can be cultivated, and as soon as the crop is removed the field should be very thoroughly cultivated before sowing to wheat. In regions where wheat is seeded down for hay any treatment of infested wheat fields is precluded. Where wheat is not followed by seeding, the fields should be ploughed as soon as the wheat is harvested.

"Thorough preparation of the corn seed bed and a liberal use of barnyard manure or other fertilizer will often give a fair stand of corn in spite of the wireworms, a vigorous plant often being able to produce roots enough to withstand the depredations of several wireworms.

"Though we realize that usually this is not practicable, the interposing of a crop not severely attacked by wireworms, such as field peas and buckwheat, between sod and corn would materially reduce the number of wireworms in the soil when the corn was planted."

With wireworms of the genus *Melanotus* conditions are somewhat different. According to observations by Mr. Hyslop, their larvae are in general confined to poorly drained, or heavy and sour soil. In many cases soil of this sort had been badly injured by wireworms for a number of years, yet after the land was tile drained the injury ceased. That tile drainage brought about the disappearance of the wireworms is not certain, but the two seem to be related in some way.

THE CORN ROOT APHIS*

Injury. The presence of the corn root aphid, or root louse, in a field of growing corn is usually shown by a dwarfing of the plants in patches over the field, together with a yellowing or reddening of the leaves. If numerous ant hills are found near such stalks, the presence of the aphid becomes still more certain, and the presence of many small bluish-green lice on the main roots indicates that the corn root aphid is affecting the plants.

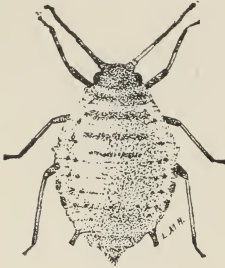


Fig. 3—The Corn Root Louse, wingless female. Greatly enlarged. (From Forbes.)

The tiny lice suck the juices from the roots, weakening the stalks and reducing the yield. The loss to the Iowa corn crop caused by the corn root aphid amounts to a considerable sum every year.

Relation of the Root Aphid and Ants. It is the presence of the ants that is the interesting part of the story. The root aphid secretes a sweet substance, known as "honey dew," of which the ants are very fond. For this reason the root lice are very well cared for by the ants, and especially by one kind known as the "little brown ant." In the fall the ants take the eggs of the root aphid down into their nests and keep them there throughout the winter. The next spring, when the eggs hatch, the ants place the young root lice on the roots of the common smartweed, or some other common weed, where the lice begin to feed. Later on, if the ground be planted to corn, the ants transfer the root lice from the weeds to the corn roots.

So the ants care for the root aphid, and in order to fight the root aphid the farmer must fight the little brown ant.

CONTROL MEASURES

Rotation. While the corn root aphid feeds, to some extent, on other plants than corn, yet a change to any other crop is about the most effective measure against this insect. Where crop rotation is carried out, with but one or two consecutive crops of corn, little injury ever occurs. What other crop is grown on infested land makes little difference; corn is by far the favorite food of the root aphid. This same treatment is also effective against the corn root-worm, which is even a more serious pest. Sometimes it is not practicable to rotate. In that case much may be done by cultivation.

Cultivation. Experiments in Illinois, made under direction of S. A. Forbes, state entomologist, have shown that a deep, thorough, stirring of the soil on old corn ground will tend to reduce injury caused by the root aphid. This stirring breaks up the nests and scatters the ants, which consequently cannot give the root lice the proper care.

Forbes says of this treatment: "The burrows of these ants do not often reach to a depth of more than 6 inches, and if plowing to this depth is followed by a deep stirring of the ground with a disc harrow, * * * the attempts of the ants to recover their property and to recon-

**Aphis maidi-radici* Forbes.

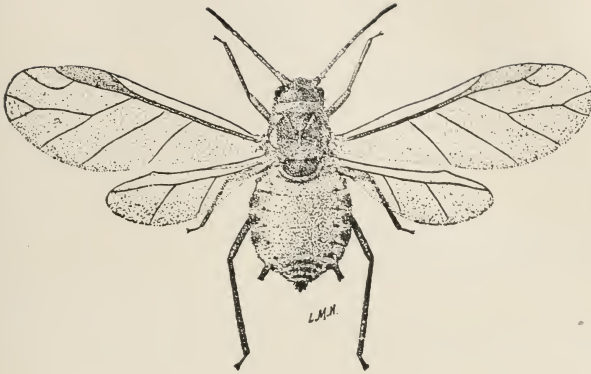


Fig. 4—Corn Root Louse, winged female. Greatly enlarged. (From Forbes.)

struct their nests are greatly disturbed and rendered largely fruitless. The more thoroughly, frequently and deeply the ground is stirred in the interval between the first plowing and the corn planting, the fewer will be the root lice in the field in the beginning of the season. * * * Fortunately the labor of this treatment of the field will usually be more than repaid by an improvement of the corn crop independent of all protection against aphid injury, this being practically the preparation for corn especially recommended by our best teachers of high-grade agriculture and practiced by some of our most successful farmers."

Life History. The life and habits of the corn root aphid are most interesting. The root lice which hatch from the eggs in the spring are all the same sex, females, which produce their young alive. Only these females are found throughout the spring and summer and not until the cooler weather of the fall do the males appear. The root lice multiply very rapidly during the summer and consequently cause much damage to growing plants. Most of them are wingless, but occasionally winged forms may be found. In the fall both the males and the females appear, mating takes place, and the females then deposit eggs, instead of bringing forth young alive. These eggs are then taken up by the ants and cared for in their nests during the winter.

Some admirable studies on the generations of the corn root aphid have been made by J. J. Davis in Illinois, who found that the largest number of generations in a single season was 22 while the smallest number was 11. During midsummer the lice matured in 7 or 8 days. A root louse only a week old was sometimes able to bear young. One root louse, then, might be a grandmother in two weeks after her own birth. In view of the rate at which the root lice increase it is no great wonder that so serious injury is caused to the corn plant.

THE CORN ROOT-WORMS

Injury. The corn root-worms are undoubtedly the most serious insect pests with which the Iowa corn grower has to contend. Their presence in a field is usually indicated by a withering of the young plants, the failure to produce well developed ears, or a general retard-

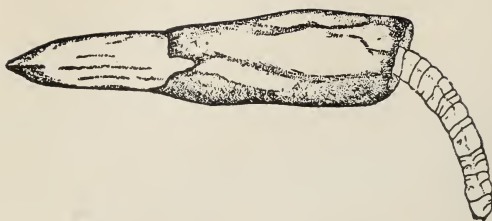


Fig. 5—Corn Root-Worm, within the root. Enlarged. The root has been broken in two, showing the root-worm still imbedded in it. (After Forbes.)

ing of the growth without any visible cause. A search among the roots of such stalks may bring to notice the tiny root-worms.

The root-worms themselves are small, slender white grubs, about half an inch long when they are full grown. Infested

stalks of corn may be pulled out easily and will break off at the place where the root-worms are at work, leaving the greater part of the roots in the soil. Frequently infested stalks are blown to the ground by the wind, the root system having been so cut off that the stalks cannot stand the strain.

Preventive Measures. Rotation of crops is the most effectual preventive of root-worms. The beetles of the root-worms usually deposit their eggs in the old infested fields. By changing the corn from such a field to another which was not in corn the preceding year, these eggs are left behind.

THE TWO KINDS OF ROOT-WORMS

There are two kinds of these worms; the "Northern corn root-worm"* and the "Southern corn root-worm."** Since the habits of the two are very different in some essential points, a few further remarks concerning them are given below. The two are easily distinguished in the beetle stage when they are commonly found on the corn silk in the fall.

The Northern Corn Root-Worm. The northern form of the root-worm in its adult stage is a plain grass-green beetle, about one-fifth of an inch long. In the fall these small green beetles are common objects on the silk of the corn and the flowers of the golden-rod. The spotted beetle of the southern corn root-worm is frequently found along with the plain green beetle. The beetles deposit their tiny eggs in the soil near the stalks of corn.

The next year these eggs hatch out young root-worms which begin to attack the corn almost as soon as it is out of the ground. Throughout the summer they work on the roots, until they become full grown in the late summer. When they become mature they change to the pupa, or resting stage, in which they spend a short time. Finally

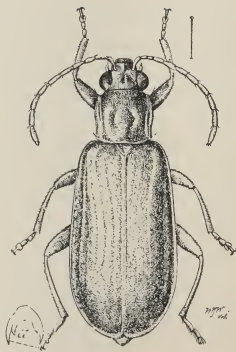


Fig. 6—The Western Corn Root-Worm: Adult, or beetle; a, claw of hind leg. Much enlarged. (From F. M. Webster, U. S. Dept. Agr.)

**Diabrotica longicornis*. Say.

***Diabrotica 12-punctata*. Oliv.

the plain green beetle emerges from this pupa. The beetles then deposit their eggs for another crop of root-worms for the next year. As far as known there is but one generation of this form in a season.

The Southern Corn Root-Worm. The beetle of the southern root-worm is green, with twelve black spots on its back. On this account it may be easily distinguished from the other form. It is also somewhat larger than the plain green beetle, measuring about a quarter of an inch long. The black spots are in three rows across the back of the beetle, each row with four spots. Usually these beetles are found along with the plain green beetles on the silks of the corn, but they are not so common. The black spotted beetles are found not only in the fall, but all through the season from early spring as well. There seem to be at least two generations of them during the year. The life history of the southern corn root-worm is similar to that of the northern form, except that it is passed through in a much shorter time. In the corn fields the eggs are deposited in the ground near the stalks.

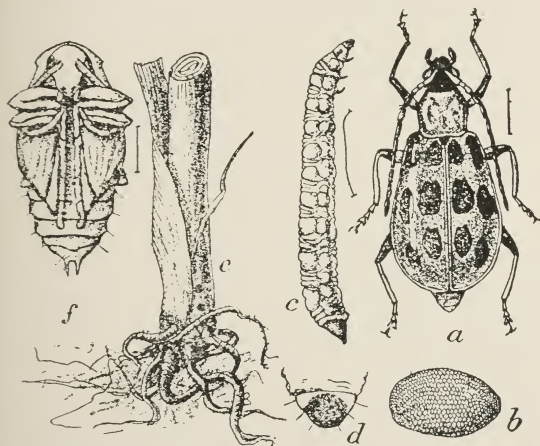


Fig. 7—Southern Corn Root-Worm: a, beetle; b, egg; c, root-worm; d, anal segment of larva; e, work of root-worm at base of corn stalk; f, pupa. All enlarged except e, which is reduced. (Re-engraved after Riley, except f, after Chittenden.) Chittenden, circular 59, Bureau of Entomology, U. S. Dept. of Agr.

Comparison of the Two Forms.

Corn is the only food plant of the northern root-worm. On the other hand, the southern root-worms have been found in wheat, rye, millet, and other grasses. The northern form does more injury to corn in Iowa. Since the northern corn root-worm has only one food plant, corn, in its grub stage, it is easy to prevent damage

by it. A mere change of crops will bring relief. With the southern form the problem is more difficult, but it is usually not the southern root-worm which does the really serious damage in Iowa.

When the plain green or the black spotted beetle are seen in very large numbers feeding on the silks of the corn in the fall, it is an indication that a corn field on the same piece of ground will be infested with the root-worms the next year. Those fields should be planted to some other crop than corn, and the corn put on a new field. Where a proper rotation of crops is put into effect there need be little trouble with these root-worms.

WHITE GRUBS*

In 1912 in northeastern Iowa occurred a very severe outbreak of white grubs. Corn on sod ground was especially damaged, also potatoes on sod ground. Certain corn fields were much more infested than others.



Fig. 8—A single White Grub.
(From Britton.)

In fact some farmers lost most of their crop on account of these grubs. A large number of species are common in the state. In the northeastern Iowa outbreak *Lachnosterna fusca* appeared to be the most abundant species concerned. For instance, out of 179 beetles collected at lights at Dubuque, Iowa, May 28, 1914, 153 were *Lachnosterna fusca*.

Damage Expected in 1915. Since the insects, as a rule, require 3 years to complete their life cycle, damage may be expected in this area in 1915. The most injury is done by the grubs in the second year, and in 1914 the parent beetles were excessively abundant in this district. Thousands of acres of tim-

ber land in this area were stripped of foliage late in May, 1914. Much of this timber was quite as bare of leaves as in winter.

Stages of the Insect. The common May beetle or June bug is the parent form of the white grub. Most people are familiar with these insects, large, clumsy, black or brownish beetles which fly to lights in May and early June. Rising from the grass where they are hiding all day the beetles move to the trees soon after sundown and remain there feeding on the leaves throughout the night.

The beetles deposit their spherical white eggs in rather compact soil, preferring sod ground. These eggs hatch and the young grubs begin to feed that summer. Grubs hatching out one year do not become full grown for 2 years, and even then the insect remains in the soil for a third winter, emerging as the beetle nearly 3 years after the egg was deposited.

For all this we may have some grubs every year, since there are so many species of these insects, maturing in different years. It is fortunate that this is the case, for when a large number of beetles appear in one season, a serious outbreak of grubs is practically certain the next year.

A generalized life cycle of these insects is better shown as given herewith. Later investigations may show that some species have a different life history, but the cycle as given applies to Iowa conditions in general.

First Year. Beetles emerge from soil in May, feed, and deposit eggs. Larvae hatch and begin to feed, wintering over in the soil.

Second Year. Larvae feed during the season. The most damage to crops is caused in the second year. The larvae winter over in the soil, practically full grown.

Third Year. Larvae feed early in the season, pupate in June or July, changing to beetle a few weeks later, but

**Lachnosterna* spp.

the beetles stay in the soil over winter.
Fourth Year. Same as the first.

CONTROL MEASURES

When the two year old grubs are in the fields damaging corn, there is no practical measure we know of to get rid of them at once, without injuring the crop. However, measures may be taken to prevent further injury and to reduce the number of insects present in any particular field. Such steps are fall plowing, rotation, or turning hogs into grub infested fields.

Turning Hogs into Infested Fields. Hogs are very fond of eating white grubs and this fact may be taken advantage of in attempting to control the insects. Hogs turned into infested fields will clear out the grubs in a short time, provided this be done before the grubs go deep in the soil in the fall. It should be done by the middle of October at least.

One drawback to this measure must be mentioned. An intestinal worm of swine, the giant thorn-headed worm,* passes one stage of its life in certain white grubs. Pigs eating grubs so infested take the parasite into their bodies. Through the pig's excrement the grubs are reinfested. It is apparent that both pigs and grubs must be present in any particular field in order that this worm may complete its transformations.

On the other hand, if young pigs, never before allowed to run out, are turned into a field that has had no pigs in it for the preceding 3



Fig. 9—Timberland in Clayton county, Iowa, showing defoliation by May beetles. Photograph taken May 30, 1914. (Davis.)

**Echinorhynchus gigas*.

years, there can be no danger. The young pigs have had no chance to become infested and the grubs in 3 years time will have all matured or otherwise gotten out of the way, so they would be free from these worms.

Rotation. Much may be done by an intelligent rotation, particularly in a district known to be badly infested. Since the grubs are not known to infest such crops as clover, alfalfa or buckwheat, these may safely follow on sod ground in a "grub year." Small grains are attacked by the grubs, but to a less extent than corn or potatoes. When grubs are expected in any particular year, corn should not follow on sod ground. It may safely be put on ground following a cultivated crop.

By referring to the generalized life cycle one may determine when to expect the grubs. For instance, if the May beetles are exceptionally abundant one year, feeding on trees at night, collecting at street lights or flying into houses, an abundance of grubs may be reasonably expected the next year. Again the grubs are likely to be abundant in 3 year intervals, in any given locality.

Since white grubs were common in 1912 in northeastern Iowa, and the May beetles abundant in 1914, then an outbreak in 1915 may be expected in that locality. Corn should follow some cultivated crop, or clover, in 1915 in order to escape injury in the region infested in 1912.

Fall Plowing. Fall plowing is of some value in grub infested fields. This brings the grubs to the surface and crushes many of them. But the grubs go deeper into the soil for the winter, consequently the plowing must be done before cold weather sets in. Early in October is the best time for this. Where the grubs are turned up in great numbers, it would be well to follow the plowing with a disc harrow, which would crush many larvae that might not be affected by the plow.

THE CORN BILL BUGS*

The Injury. When growing corn is but a few inches high the tender leaves are often injured by rows of holes cut across the blade. Where severe, the injury causes the growing plant to be greatly stunted. This kind of injury is most likely to occur when corn directly follows timothy sod.

These holes are made by the corn bill bugs. As it may be guessed, the injured blade is still within the sheath of the corn stalk when the damage is done, and the holes do not become conspicuous until after the blade has grown out. Since the blade is curled up within the sheath, one hole made in the sheath will unfold and make six or eight holes in the blade.

The Insect. There are several kinds of these bill bugs. Most of them are black or brown in color. One kind is clay colored. All are beetles with hard backs, and with a long snout with which the holes in the corn blades are made. In this grub stage the corn bill bugs feed on the roots of certain grasses, one of the most common species feeding on timothy roots. So when corn is put on timothy sod that has been infested with these grubs, the mature bill bugs are very likely to take to the corn as soon as it comes up, especially if the sod is turned under in the spring.

**Sphenophorus* spp.



Fig. 10—Corn plant injured by a bill bug
From Babcock. (14th Rep. Minn. State
Ent.)

tends to reduce greatly the injury to corn, if that crop is put on the field the following year. Apparently the stirring of the soil so disturbs the insects that they are unable to survive the winter.

CUTWORMS*

Cutworms are most troublesome to corn when following sod. The injury to young corn plants is known to most farmers, the cutting off of the stalk at the base of the plant, at or just below the surface of the soil. This injury is hard to confuse with that of other corn insects. Usually the insect responsible for the damage may be found in the soil near the plant attacked.

The Insect. Full grown cutworms are about $1\frac{1}{2}$ inches long, usually dull in color. Rarely, as with the variegated cutworm, are they well marked or striped. Mature larvae form loose cells in the soil, change first to the intermediate pupa

Life History. Apparently there is in this latitude but a single generation of these bill bugs in a year. Dr. Forbes, Illinois state entomologist, has found such to be the case in that state. In general the insects spend the winter in the beetle stage and the beetles cause the damage to corn in the late spring. In the early summer the beetles deposit their eggs on timothy and other grasses, and finally disappear. The eggs hatch and the young grubs feed in the grass roots until early fall, when the adult beetles appear. Before changing to the beetle form the grub enters the pupa, or the inactive stage, which comes between the grub and the adult beetle. This completes the life cycle. Since there are several species that are concerned, the details of the life history vary with the species.

Control Measures. It has been found that the early fall or summer plowing of sod lands, which are infested with these grubs,



Fig. 11—One of the common bill bugs. *Sphenophorus venatus*.
From Washburn. (14th Rep. Minn. State Ent.)

*Various species of Noctuidae.

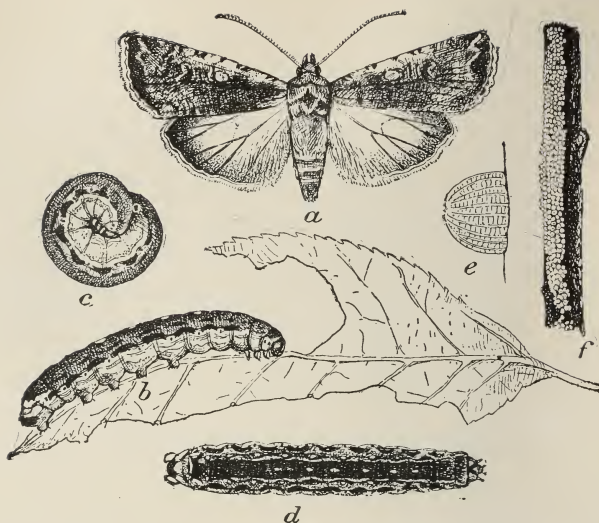


Fig. 12—The Variegated Cutworm: a, adult; b, c, d, full-grown larvae; e, f, eggs; all natural size except e, which is greatly enlarged. (From Howard, U. S. Dept. Agr.)

stage, few days later to the parent moth. Moths of the various species are much alike, all of them dull in appearance and brownish in color with the hind wings somewhat lighter than the fore wings. These moths deposit eggs, from which the young cutworms hatch.

Life History. In general most cutworms spend the winter partly grown. Consequently they are already good size by the time the young corn plants are pushing their way through the ground. They become full grown late in June, or early in July. One often hears the statement that hot weather kills the cutworms. Such is not the case, however. Hot weather merely gives them a better chance to grow and they complete their transformations and enter the pupa stage. Favorable weather hastens this, but does not kill the insects.

Later on in the summer the adult moths issue from these pupae and deposit their eggs in grass lands. Young cutworms feed there, growing slowly, going below the soil around the plants a short distance, where they spend the winter. As a rule the different species of cut worms have only a single generation annually. But there are exceptions to this for two or three broods of larvae occur in some instances.

Control Measures. When cutworms are present in a corn field there are only two measures to be taken. The first, replanting, should be delayed until the damage by the insects has practically ceased. The second measure is poisoning. A poison bait may be made by mixing one pound of paris green with twenty-five pounds of dry bran or middlings. Scattered over a corn field this bait attracts the cutworms, which feed on it and are killed.

Early fall plowing of grass land to be planted in corn the next year is a preventive measure advised against cutworms. This buries

the eggs or young larvae, putting them out of the way so they cannot live over winter. Fall pasturing of such land is also a benefit, provided the grass be eaten down close. This starves out the cutworms in the fall. Corn land should be kept as free of all vegetation as possible in spring, so that there may be as little as possible for the cutworms to eat before the corn comes up.

THE CHINCH BUG*



Fig. 13— The adult Chinch Bug.
(From F. M. Webster, U. S.
Dept. Agr.)

Although chinch bugs have not caused damage to corn in Iowa in recent years some space may be given to them, since they have been abundant in the past and may cause great injury again in the future. Last year, 1914, this insect caused great damage in central Illinois, and according to observations in that state was working its way towards the Iowa boundary.

In 1887 in Iowa chinch bug injury was noticeable in three-fourths of the counties in the state. According to an estimate made by Prof. Herbert Osborn at that time the loss to the state amounted to \$25,000,000 in that year.

Injury to Corn. Damage to corn occurs, for the most part in midsummer, when the growing bugs pass from ripening wheat to corn. It does not necessarily follow that the chinch bug will not become dangerous in localities where no wheat is grown, although such is likely to be the case.

Chinch bugs take their sustenance by driving their beaks into plant tissue and extracting therefrom the juices for their own benefit. This makes the insect all the more difficult to control, since no arsenical poison is of any use against it.

Description of the Insect. The adult form of the chinch bug (fig. 13) is about 1-5 inch long, black in color, with the under wings whitish. These wings cross on the back of the insect, forming a sort of an X-shaped mark. The eggs are very small, 3-100 inch long, oval in shape, with one end cut off square. The eggs are pale at first, later amber in color and still later reddish.

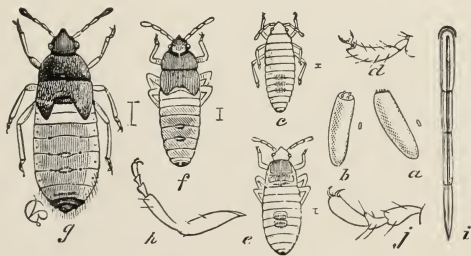


Fig 14—Chinch Bug a, b, eggs; c, newly hatched larva, or nymph; d, its tarsus; e, larva after first moult; f, same after second moult; g, last-stage larva; the natural sizes indicated at sides; h, enlarged leg of perfect bug; j, tarsus of same, still more enlarged; i, proboscis or beak, enlarged. (From Riley.)

**Blissus leucopterus* Say.

Young larvae, or nymphs (fig. 14) are pale yellow at first, becoming quite reddish later on. At first there are no traces of wings but in the later stages the wing pads appear. The nymphs moult, that is, shed their skins four times, with slight changes each time. After the fourth moult the insect becomes an adult.

Seasonal History. During the winter adult chinch bugs hibernate in clumps of dried or matted grass and other vegetation. In April they scatter from their winter quarters and settle mainly on wheat, which offers an abundance of food at this time. The old bugs soon deposit their eggs in such situations and their young feed there.

All the old bugs are dead and the young ones have not yet developed wings when the grain is cut. But the bugs must go to green food, and since they are unable to fly, necessarily must crawl from one field to another. Growing corn at this time offers especially tempting meals to the partly grown chinch bugs and the fight of the farmer is to keep the bugs out of the corn.

When the insects mature, sometime in July, they in turn deposit eggs for a second generation of chinch bugs. This is likely to be in corn, if the insects are abundant. These bugs grow rapidly in mid-summer, causing great damage to corn where they are common. In September again the insects mature and spend the winter as adult bugs.

CONTROL MEASURES

Destroying Bugs in Winter Quarters. Since the chinch bugs hibernate in clumps of wild grass, and similar situations, much benefit may be obtained by burning this. Burning is best done in the fall, since such bugs that are not killed outright are left exposed to the winter with inadequate protection. In Kansas burning has been practiced on a large scale, with great benefits.

Clean culture in general is a measure of no little importance. The less grass or weeds in a field, the less chance there will be for the bugs to hibernate therein.

Barriers. As wheat harvest draws near the owner of a field infested with chinch bugs should take measures to prevent the insects from entering other fields, especially corn fields. This is best done by making barrier lines around the infested field, using some repellant for this purpose. Probably the most thorough work of this nature has been done in Illinois, under the direction of the state entomologist, Dr. S. A. Forbes. In that state the materials most used are road oil No. 7 as manufactured by the Standard Oil company; crude creosote (containing 8 or 10 per cent tar acids) or crude carbolic acid. These last two materials may be obtained from any large wholesale drug dealer. The road oil has proven the best material for this purpose but this oil must be ordered in advance and is used only for this purpose.

The first step in making a barrier around an infested field is to prepare the ground for a path. The precise manner in which to do this will vary with different soils. Usually the experience of the individual farmer will determine just how this may best be done. A bare, rather firm and reasonably level surface only is necessary for the creosote; for the road oil a hard smooth surface is essential. The road oil must be kept so sticky that chinch bugs cannot cross it but the creosote acts on account of its repellant odor. So while the latter may soak into the soil and still be effective, this is not true of the former.

One of the simplest ways of making a path around an infested field is to drag a heavy plank until a smooth surface is obtained. If this plank is cut to a V shape at the front, with sharp iron strips attached to both sides and a small share in the center, still better results may be accomplished. A small square piece of iron, placed on the under side of the plank, about the middle, will make a groove in the path for the oil.

In laying the oil line almost any kind of a container may be used; a pot with a tubular spout, or even a tin pail with a hole driven through the side, close to the bottom. The stream should be half an inch thick or more, about the width of one's finger and a hole in the pail made by a 6-penny or 4-penny nail is sufficiently large for this. Walking at a normal pace along the path with the pail a person may lay the oil or other material down in good shape.

Post holes 18 inches to 2 feet deep should be dug at intervals of about 20 feet, just inside the oil line. These holes catch the bugs, which are unable to cross the line. By pouring a little kerosene into these holes when bugs collect in them, all of them are killed.

These barriers, whatever the material used, must be kept freshened. Road oil must be renewed just as soon as the surface becomes a little hardened, every 2 or 3 days, varying according to different conditions. But with the creosote and carbolic acid it is necessary to renew the line every day, at least for a time, and every other day while the insects are active. All this seems like a vast amount of trouble, but when it comes to a choice between these measures, and probable total loss of a corn crop, it is the only thing to do.

Dusty furrows. This is merely a furrow around a bug infested field, kept dusty by continuous dragging. The temperature of this furrow in hot weather is extremely high and large numbers of the young bugs are killed when they attempt to cross it. The main objection to the dusty furrow is that it is not equally effective on all kinds of soil and that a slight shower necessitates additional dragging. It is not nearly so good a measure as the oil barriers.

A double furrow around a field has proven much more desirable than a single one. By fastening together a couple of logs 12 inches apart, or better still two heavily laden troughs, these may be dragged around a field where a path has been previously prepared by plowing.

Spraying. Once the bugs are in a corn field there is only one measure available, spraying the infested plants. If this is done when the insects first enter the field, a great deal may be accomplished.

In Illinois the tobacco extract known as Black leaf-40 has been used for this purpose, $\frac{1}{4}$ ounce in one gallon of water, adding an ounce of soap. Soap alone, three ounces to a gallon of water, proved nearly as effective as the tobacco extract, according to Doctor Forbes.

THE CORN EAR WORM*

Injury. This is the common greenish or brownish "worm" that eats into the ears of both field and sweet corn. It is especially a pest to the latter in Iowa, and in some years, very destructive to the former. Unfortunately there are no very practical measures for its control.

**Heliothis obsoleta*. Fabr.

The young larva begins to feed on the silks, soon eating into the grains of corn at the tip end of the ear. As it grows the larva tunnels down the ear toward the butt end, eating only a part of the corn, yet injuring the whole ear so far as market purposes are concerned.

The Insect. The eggs are small, white, rather spherical objects, usually deposited on silks of corn. Mature larvae measure about $1\frac{1}{2}$ inch long, varying in color from light green to brown, more or less striped in appearance, with alternating light and dark lines.

The intermediate pupa stage is brownish in color, stout and $\frac{3}{4}$ inch long. The moth, a rather stout insect, is $\frac{3}{4}$ inch long and $1\frac{1}{2}$ inches across the outstretched wings. It is dull yellowish or drab on the forewings, with darker markings. The hind wings are drab, darker toward the outer margin.

Life History. The corn ear worm spends the winter in the pupa stage in the ground. Sometimes in late spring, in May or June, the adult moths emerge and deposit their eggs, mainly on sweet corn, although these are not specially common. Around Ames the first mature larvae are found in July. In August especially in sweet corn, larvae become very abundant. With favorable weather conditions in September and October these larvae may still be found. Even after corn is hardened they may attack clover or alfalfa. Such was the case in October, 1914 in extreme southwestern Iowa.

The number of generations in the state is a matter of doubt. Probably it varies with favorable or unfavorable conditions. Three generations are quite probable.

Control Measures. At present there appears to be no reliable measure for combatting the corn ear worm in corn. Fall plowing has often been recommended against this insect but it is doubtful if this really is very effective. The insects breed with such extreme rapidity during the summer that it may overcome easily any benefit fall plowing would bring about.

Some benefit has been obtained by dusting sweet corn during the silking period with powdered lead arsenate. In fact, this has been tried out here in Iowa with some degree of success. But at this time the method has hardly passed the experimental stage, and so cannot be generally recommended.

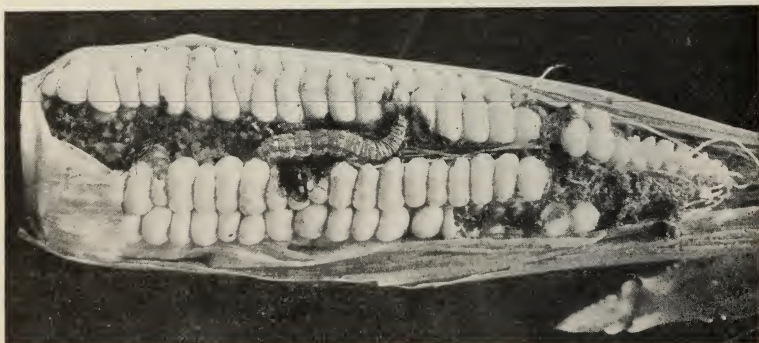


Fig. 15— Corn Ear Worm in sweet corn. (From Quaintance & Brues, U. S. Dept. of Agr.)

July, 1915

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Circular No. 24

THE SURVEY AS A GUIDE TO RURAL SOCIAL PROGRESS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS



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The Survey as a Guide to Rural Social Progress

By George H. Von Tungeln
Associate Professor of Rural Sociology.

PART I—MEANING AND PURPOSE OF A SURVEY

A rural social survey is an inventory of the factors which are at work, either favorably or unfavorably, in the economic, educational, moral, political, religious and social life of a rural people. Its purpose is to do for the community what the physician does for the patient when he makes a scientific diagnosis of the case and then follows this with a treatment designed to remove the trouble. Or it aims to do for a community what the chemist does when he makes an analysis of a compound and classifies the ingredients, and labels each class for just what it is, without respect to anything except the truth as the analysis has revealed it to him.

Such a survey is in harmony with the modern spirit of scientific study or research, which always has for its great aim the helping of men to better and happier living.

Civilization has advanced to the level where mistakes are very costly, and science is leaving no stone unturned to enable the human race to steer clear of as many mistakes as possible. So investigation, or research, today is not intended merely to find a means for restoring abnormal and undesirable conditions to the normal and desirable, but also to determine means of prevention and invention; prevention of that which would be undesirable and invention of that which will increase human well-being or happiness. The purpose of civilization is social progress, and to point out the way to this goal is the business of science. If applied with common sense, science will set both the danger signals and the sign-posts along the path which an advancing civilization must tread.

With the advancement of civilization comes an ever growing movement toward a greater complexity of human relationship and an increasing interdependence of individuals. Civilization today is a specialization of life's work and a generalization of life's experiences into an enlightened citizenship, both in the individual and in the social aggregate. It is the constructing and inventing of that which is *pro-social* or that which is the means to a better and happier life, and a prevention of that which is *anti-social*, or that which tends to degrade human-kind and to impair human well-being.

Never was it truer than today that "man lives not unto himself alone." All men, rich or poor, must live with and among their fellow-men. They associate one with another. They must think, aim and act unitedly as well as think, aim and act individually. It becomes all the more important, therefore, that men know how, when and what to think, do or aim for; where and how to take hold; and where and

when to let go. In order that all may know these things, they must know, and know well, what conditions prevail in their community. But it is absolutely impossible for every man to investigate for himself all those community conditions which vitally concern him. Neither would it be economy or make for efficiency for each to do so, when a few trained individuals could make a scientific study of the community and then portray the conditions found by them so graphically, so simply and so truthfully that all may readily know the real facts.

Such a true-to-life picture of the community is to be obtained only by a careful and accurate survey. Professor Groves sounds the key-note when he says: "The trivial happenings of a locality are not difficult to know, but the causes of these events present a different problem. To meet the need of knowing 'the present state' of the community has arisen the rural survey." Again he says: "Recently when a gathering of rural workers were asked whether they had a rather definite knowledge of social and moral conditions in their several communities they all responded affirmatively and with confidence, but when questions calling for specific knowledge were asked nearly all at once admitted their ignorance."¹ The fact is that almost everybody knows considerable in general or vaguely about his community, but little or nothing definitely and specifically.

Just how little is definitely known by the people of any community is at once revealed upon asking for definite information from even its more intelligent and wide-awake members. The vague answers, or absolute failure to give any answer at all, to such questions as deal with the birth and death rate, public health, school attendance, truancy, crop management, community organization, religious affairs, dairy production, etc., at once reveal this even to the uncultured.

Yet all this information, and much more, is essential to the wisest procedure in matters economic, educational, moral, political, religious and social, as they relate to the life of the local community and to the development of the state and the nation. Of course, not every member of any community could be expected to have made such a careful study of his community as would enable him to know all these things, for he doesn't have the time, but should he not really know these things and would knowing them not help him to talk more understandingly of his community, to act more rationally, to vote more intelligently, to farm more successfully, and, last of all, to live more safely and happily? If this is true, then would it not pay the community to have an inventory of the community made and in this way discover the answer to all the questions which may come up and which are vital to the particular community and also to the state and nation?

But often men say, either in words or in actions, that "what I do is no business of my neighbors." That could be true only where there were no neighbors, but such a case does not exist, for no man lives unto himself alone. We have not yet been able to legislate to compel

¹ Rural Manhood, Oct. 1914, p. 342.

the birds of the air and the wind, for example, to recognize line fences. The result is that if a neighbor has hog cholera among his hogs, his, his neighbor's or some other person's pigeons will light in his hog pen and take up the cholera germs or bacteria and carry them to the neighbor's pen. Or again, one neighbor may carelessly or thoughtlessly contaminate the stream from which the man farther down secures his water supply. It is true that "we are our brother's keeper," but it is also true, and too often so, that we are our brother's or our neighbor's killer, by contaminating the food he eats, the water he drinks or the air he breathes.

THE PURPOSE OF A SURVEY

While the average person can give little definite or scientific information concerning his community, yet this knowledge concerning the life and conduct of the people is most vital. Nevertheless, there is often an erroneous idea that the purpose of a rural survey is to "show up" a community. This is not its purpose. The purpose of such work is to get a real picture of conditions which all wide-awake members of the community want corrected, but which they perhaps have not been able to correct because they knew not how or where to begin. The survey, in other words, merely makes a diagnosis of the community's institutions, activities and modes of living and so enables leaders to point the way to social betterment or to guide the people to greater well being. The survey is merely a stock taking.

When a survey is undertaken it should be fearlessly done and in a painstaking way, so as to secure all the facts, and these just as they are, uncolored by the prejudices of any individual. When conducted in this way and when the data are carefully and properly tabulated, the results will be a picture, true to life, of the community studied. It will, however, be a true-to-life picture only of the community studied, for the conditions in no two communities are exactly alike, no more than two individuals are exactly alike. It may be a cue or an "eye opener" to other communities, but it cannot be an exact guide to them. It belongs first and last to the community of which it is a real part and to which alone it can be a true guide to a better and happier community life. It can be made the true basis for the development of rural leadership, for it gives to the latent talent for such leadership that is to be found in every community an insight into what the community might be, what there is to lead the community to, and what there is from which the community should and would be led. It points out both the stumbling blocks and the stepping stones to progress. It is a community's safest, surest and most economical way of doctoring itself or curing its own sores.

That every community has some ills or sores is no false presumption. For any community to aver that it has none would be presumptuous. To think that no good could come from careful study and the revealing of the facts as they exist in any community would like-

wise be presumptuous. It is well known by all sane men that there is no perfect community, no more than there is a perfect man. However, if men can improve their own lives, then communities which are comprised of men, and directed by men, can also be improved by men. It is to reveal the way to such improvement that the social survey is to function, and only to this end is it to function.

The object or purpose of the survey then is not to "show up" the community, but to "build it up," and this by its own action, the only safe and true way to community improvement. The community that is having a survey made is not a community that is dead at the top and has closed itself in by its own shell of self-conceit, thinking that it is as good as can be and that there is no place for improvement, but is a very wide-awake community which still has a consciousness that prompts it to improvement. It is a community which knows that something in the way of improvement is possible and so is going after that improvement along the most scientific and economical lines. Such a community is a long way in the lead of the other type of community above described. It is the leader and not a drag among communities. It is the community to which the other type of community will look for helpful suggestions when once it awakens from its lethargy, if it ever does.

THE VALUE OF THE SURVEY.

The value of any piece of research work depends upon the amount of truth which it reveals. Just how nearly the survey, in the case of this type of research or investigational work when all the data are collected and tabulated, actually reveals the conditions as they really exist will depend upon two things. The first, and by far the most important, is the extent to which the people of the community tell "the truth, the whole truth and nothing but the truth" about themselves and their activities to those collecting the data. If the members of the community tell but half the truth, it would be hardly fair of them to expect more than "half results," so to speak, or to realize more than half the possibilities which lie in such a piece of work. If very work. That would be merely fault finding without offering any only corn is planted, it is hardly fair to expect to harvest both corn and beans. The second determinant of the value of such a piece of reesarch work is the accuracy with which the data are collected and tabulated. The person, or persons, carrying on the investigations should, therefore, be of the painstaking and scientific type of mind.

Since, then, so much depends upon the attitude which the persons who comprise the community studied take toward the investigation, it is at once apparent that it is both useless and foolish to attempt a survey of a community unless its people are willing to supply the investigator with all the information they have at their command. Whether they will be willing to do this is a matter for them to decide as well as to how and with what degree of accuracy it is to be studied.

If a community is really anxious to better its own conditions, then its first step must be to determine its present status or conditions, in order that it may know precisely just what it has and has not, and what it wants less of. To this end the social survey is a proper means, and should always and only be made a means to such an end.

Merely to "show up" a community is not the aim or ideal of survey work. That would be merely faultfinding, without offering any solution for the difficulty. Such may be a field of work for an individual who has "soured on" society, but it can never be the aim of the scientist nor should it be the result of a scientist's work. Survey work is scientific work not petti-foggery. It aims at building up a community not tearing it down. It is a ladder on which the community may climb to the head of community ranks. It has been such in communities which have had their own conditions scientifically studied, and thereby have had pointed out to themselves and discovered for themselves the way to improvement, improvements in their economic, educational, moral, political, religious and social activities. It has made such communities both a better place in which to live and a more profitable place in which to live.

What the survey has done for some communities it can do for any community. It is merely applying science to community life and its activities just as the farmers of today apply science to grow two ears of corn where their fathers grew one, and in that lies both a profit and a pleasure. In making a survey of our community life, first, to determine why its conditions actually are as they are, and secondly, to build on and with that which there is in a community which is essential, we may hope to accomplish most. In this lies the realization of growing two grains of happiness where before there was but one, and this one perhaps contending with a grain of corruption for supremacy. In this, too, there lie both a profit and a pleasure, for happy men and women produce more and better things than do less happy or unhappy ones.

PART II—THE METHOD OF PROCEDURE

The method of making a survey must be simple and scientific. For it must be remembered that it is to be, so to speak, a photograph of the community, and when the data are finally tabulated and plotted the photograph should be as nearly an exact likeness as is the picture of a camera. Likewise, in this connection it should be remembered that the only way that it is safe to use a community for laboratory or clinical material is to cure its sores in the use or process. This is especially true in our country, where, as one writer has expressed it, "The American mind is so eminently practical and measures values in terms of concrete returns." Methods used, then, that are not in the best keeping with this fundamental factor in the American temperament will not produce the greatest possible results.

There are at least two different types of surveys. These may be designated as "extensive surveys" and "intensive surveys." The object of these two kinds of surveys is usually somewhat different. The method pursued in either case is also usually somewhat different from the other.

In the case of the extensive survey, a much larger area is usually covered than in the intensive survey. In the case of the extensive survey, the usual purpose is to determine the facts concerning certain conditions or activities which are more or less common to all parts of the area covered. Such a survey is the United States census taking. Such a study reveals facts as they exist on the whole, but it makes no great attempt at stating just what particular farmer has a sick herd or raises thoroughbreds, etc. It merely states how many thoroughbreds are raised in the section covered by the study. Its work is somewhat like that of the chemist who makes an analysis of a given solution or compound to determine whether or not it contains, say sulfur, and having determined that, he does not go on to determine what other substances are to be found in the same solution. In this way a much larger number of solutions can be analyzed than could be analyzed if all the substances which are to be found in the solution were to be determined. In such a case sulfur might be taken from the solution, since it made the solution unfit for a particular use, but if no further examination of the solution were made, it might still prove, upon use, that the solution also contained something else that made it unfit for many uses and conceivably even for the same use for which the sulfur made it unfit.

In case of the intensive survey, the area is more restricted and limited. It aims to study an area where there are many more things which are common to all the persons and activities within the area than are to be found in the larger areas, usually covered by the extensive survey. The intensive survey aims not only to determine how many sick herds there are within the area and how many thoroughbreds there are, but just who owns or raises them, and how they are raised and with what success. In case of the intensive survey, the chemist would try to determine most, if not all, of the substances in the solution and label them accordingly.

In the case of the intensive survey, therefore, the area studied should be one throughout which the conditions are much the same. In such a case, local units, such as townships or communities which have a common trading center, should constitute the field to be studied. Many such areas may be studied and the facts found to exist in each compared with those found in others. But if several such units should be lumped together and studied as a unit, much of the valuable information which was characteristic only of certain parts of the larger area would not appear as it should and in a way which would serve as a guide to the people of that part or those parts of the larger section.

Therefore, in all survey work it should first of all be determined

how much of a detailed study is to be made in order to determine, next, the extent of the area to be studied. This is essential because extensive surveys and intensive surveys do not mix well. If they are mixed it usually happens that the study is not extensive enough to safely admit of deductions, the chief purpose of the extensive survey, and at the same time it will be too extensive to admit of induction or to reveal the facts in more minute detail, which is the chief purpose of the intensive survey or study.

WHAT SHOULD A RURAL SOCIAL SURVEY INCLUDE?

A rural social survey, to be of practical value, must follow lines that are practical and must be made with a view to offering a feasible plan for improvement which can be readily understood and carried out. But to make such a survey requires an intensive study of all the institutions, organizations, conditions and activities of the community of which the survey is made. The necessity for the study of all these forces follows from the fact that the social center and the business center of the rural group are both located at a common place, namely, the farm home. It is the rural home that is the birthplace of the arts and crafts and the persons of the rural group. And so since both the business system and the social system or life of the rural community are centered in the rural home, it follows that anything which in some way influences the rural group on either the social or the industrial side of its life also reacts upon it in the other, even though this reaction may be opposite or reverse in character.

Since, then, the rural survey, if to be practical, must include a study of the economic, educational, moral, political, religious and social phases or characteristics of the community, we may consider next just what definite information concerning these different phases of the community's life and activities the expert, or social engineer, who is making or directing the study, should ascertain in the investigation. The lines to follow in securing such information can best be pointed out by considering these phases of the community's life and activities separately. Of course, it must be remembered that this is merely an arbitrary way of dividing the entire subject for convenience of study and that no such hard and fast lines can actually be drawn in practice between any two of these phases of a community's life and activities.

A survey of the economic situation or conditions of any particular community must determine to what extent the community in question is a large-scale farming, truck farming or manufacturing community; what are the methods of land tenure and land ownership; the extent to which all land is improved and under cultivation; what are the prevailing crops; what are its transportation facilities, such as roads, waterways and railroads; the distance the farm is from the nearest market center; the growth, decline or recent changes in its methods of farming or industry; the scarcity or abundance of labor, the wages of labor and the extent to which laborers are imported in rush sea-

sons; the conveniences and equipment in the home and on the farm, and finally, it must determine the general financial status of the community, together with the information as to whether the old settlers and their descendants are holding control of the community interests or whether new arrivals are getting control.

That part of the survey investigating the educational aspects of the community is concerned primarily with a study of the population, the total number of individuals in the community, the total number of persons below public school age, the total number of school age, and the total number above public school age. It must ascertain how many adults are illiterate, how many mentally abnormal persons there are in the community and the number in institutions of sick-in-mind and sick-in-body from this community, what per cent of the children of school age are enrolled in school, the average attendance of all, how many are in high schools and in institutions of higher learning, and a comparison of the education of the tenants with that of the land-owners. In this same connection it must include the study of different nationalities in the community, the native and foreign-born adults and minors and the comparative education and school attendance of these. Furthermore, this part of the study must make a complete study of all the schools; one-room schools, centralized schools, high schools or academies and schools of higher learning in the community, the qualifications of the teachers, the line of work done, the relation of these institutions to the industries of the community, libraries, clubs, societies and organizations which offer educational privileges and advantages, the equipment and apparatus of these institutions and the efficiency with which all are used and managed, together with the sanitary conditions of the same.

The study regarding the moral status of the community must be made with great care and every possible source of checking up the information on this aspect of the community life should be utilized, for the reason that people are more likely to deviate from the truth in the information they give on this than any other aspect of a community's record and reputation. Much of the criminal and court record of the community can be gained and checked up by information secured from court officers, justices of the peace, other officers of the law and their records. Much valuable and reliable information concerning the social vice and its consequences can be secured from the physicians and ministers of the community, when once these men have been convinced of the honest intent and purpose of making the study. This phase of the investigation should reveal the facts concerning the business ethics of the people of the community, their standard of public and private morality, the standard of morality for the two sexes and the relation of the sexes, the number of illegitimate children, still-births, divorces, intermarriage of close kin, doctors' records of venereal diseases, sexual perversion generally, juvenile and adult delinquency, number of representatives in reformatory or industrial

and penal institutions, lawsuits, intemperance, excessive use of tobacco, habits of graft, gambling and profanity.

Concerning the political status of the community, the investigation should bring out to what extent the community is in the hands of political bosses, to what extent the men and women who hold the political offices actually use their influences and render their services in the interest of the community as a whole, to what extent the legal voters actively participate in all matters concerning the community and vote in elections, the extent of vote buying and loose handling of public funds, the open-mindedness with which people of one political party are willing to listen to the policies and platforms on which representatives of other parties stand, the attitude taken toward recent changes and proposed changes in local, state and national government policies.

The study of the religious life of the community will involve a careful study of all the institutions that are primarily, or to a considerable extent, religious in character or of a religious function. This will involve a study of the churches, Sunday schools, young people's societies, such as Epworth League, Christian Endeavor, etc., brotherhood clubs, missionary societies, Young Men's and Young Women's Christian associations, and all other organizations, societies and clubs of similar nature and purpose. Such a study will involve a study of the membership of these institutions and organizations, their influence in the community, a study as to their growth or decline, the attitude the people have toward them and the support given them, how generally they fill the place in the life of the community that they are intended to fill, and finally what attitude these different institutions take toward the social life of their people and the degree of co-ordination and co-operation there exists among them in forming a united front against those things in the community which they cannot sanction.

In the study of the social aspect of the community, it must be remembered that the word social is here to be understood in the broader meaning of the term and that, therefore, some of the forces and factors that are here to be considered might also have been classed under one or more of the above subjects. This is true for the reason that they have in them not only a social aspect, but in many cases an economic, educative, moral, political and religious aspect also. It is almost always true, or should be, that factors and forces which function in the social life of a people also function in one or more of these other aspects of a people's life.

First of all, such an investigation must seek to ascertain the relation of the homes to the members of the family and to the community in general, the uses the home is put to in the family life and in the neighborhood or community life. Then there must be a study of the recreational, amusement and entertainment facilities which the homes and the community, or other organizations and agencies of the com-

munity furnish for all the people, both as to facilities that are adapted to persons of different ages and as to facilities which can be participated in by persons of all ages on a co-operative or collective basis. This will involve a study of all clubs, societies, organizations and agencies that are wholly or partially of a social character, and which represent all the age groups. A study must also be made of the relief, sanitary, health, protective, civic, educational and cultural agencies and conditions and of the institutions and provisions for the aged and infirm, the homeless, and any other agencies and conditions which have not already been mentioned above. Then, finally, there must be included a study of all these institutions and agencies to determine whether or not they are sufficient for the needs of the community, how they are maintained and to what extent there is a useless over-lapping of the parts of the field in which they function and to what extent there is an overlooking of some phases of the field where the interests of the community are not looked after.

A TABULATION OF THE DATA.

To make an intensive and scientific study of a community is no small undertaking and the best way to secure all this information is to take a census of each home, organization or society and institution of the community. When this is done, then a study of the lay of the community, such as the relation and location of the homes, institutions, roads, streams, libraries, social centers, etc., to each other should be made. All the information so collected should then be put in verbal, graphic and simple statistical form in just so far as that is possible. There should be, first, a series of maps or illustration, each of which shows only one or two definite things. As for example, there could be a map or graphic illustration showing the relation of tenant to land-owning farmers and farms. In a similar way, the number of tenant farm homes represented in the different clubs and organizations as compared with the land-owning homes so represented, the location of libraries, clubs, etc., the representation of homes that have modern conveniences, homes of no children, of one child, of two, three and four or more children, the location of the one-room and the centralized or consolidated schools, the enrollment and daily attendance of each, the proportion of children in high school compared with those in elementary schools and those who have finished the eighth grade, the distance of the home from the school, homes having private libraries, magazines, etc., the growth and decline of churches, churches and schools used for various purposes, relation of church going to membership in other organizations, clubs, societies, and so on, almost indefinitely. Much of this can be expressed or illustrated in graphic form. And from all that is so illustrated in such a group of maps or plats there should then be made one or two large maps showing all these things in their proper relations and positions. Such a graphic illustration is of great value, for just as light travels faster than sound, so

the average individual gets a deeper and better impression from a visual than an auditory sensation. Or as some one has put it, "you can pour more into the mind of the average individual through the eye with a teaspoon than you can with a scoop-shovel through the ear." From such maps of all the agencies at work in his community, the individual carries with him a clearer picture of the community he lives in than in any other way.

But the individuals of the community will not only get a clearer picture of their community, but from what the picture reveals they will at once begin to overwhelm each other with such questions as: Why do so few of our tenants join the clubs, societies, etc.? Why do so few of our children attend high school? Why is this family or that family never seen at any of our meetings? How is it that Farmer John always grows better crops than any one else in the neighborhood? Why can't we have more joint meetings of a number of our clubs? Why don't the parents visit the schools more? Where are we going to take hold first in changing some of these things? Can we unite the forces of a lot of our organizations so as to remedy some of these things which no one of them can do alone? What are our different organizations doing that works for the good of the community in general in order to increase general prosperity, and which in turn keeps their own enterprises above water? And so one might go on citing many other questions which will be asked when the people of the community stand face to face with a true-to-life picture of their community. "These questions," as Professor Galpin of Wisconsin University says, "are vital blows upon hard problems, and are bound to crack open solutions."

WHO SHALL DO THE WORK?

Who shall make the survey?

The first part of the answer to this question is, that one person, or perhaps two, should direct and supervise the work. In some cases the rural minister is quite competent to do this. In other cases, a county agriculturist or a county Y. M. C. A. secretary may be able to direct and supervise the work, providing he has the time and inclination to do so. If, however, the community wishes to have some one from outside of its own borders do this part of the work and tabulate the results, which is no small task, the colleges of the state can usually furnish such a person at a small cost, or without any direct cost to the community.

In any community there are usually a few social-minded individuals who could quite competently take the home and the organization census. These persons can often be so utilized. In a similar way, a group of broad-minded and social-minded individuals of the community should be chosen to constitute a survey committee, who would give the director every possible support and give the work a dignity and enthusiasm that would prevent any possible feeling that might grow up that the community is merely to be "shown up," which danger is at

least quietly present, especially if the director is not a citizen of the same community. In some cases it may be necessary or advisable to bring in, as helpers to the director, some persons from outside the community. If, on the other hand, a minister is to direct the work, care must be taken to get on the survey committee representatives of all the churches in the community or otherwise some one will say that "the Methodists, Baptists or Congregationalists, etc., as the case may be, are doing this for their own selfish ends and so I want nothing to do with it." If these difficulties can be avoided and some minister can serve in the capacity of director, it will mean the most valuable bit of experience for him that he ever got. It will give him an acquaintance with his community and his people such as he would get in no other way. No doubt Prof. T. H. Carver is right when he says that "a survey of a parish should be undertaken by every candidate for the ministry, particularly the rural minister, before he is turned loose to practice upon a parish."

RECAPITULATION.

The intricacies of human society and the state of interdependence of the individuals of society has reached such complexity that neither individuals nor communities can afford to attempt things except in a common sense and scientific way. Neither can the individual nor communities afford not to know what are really the factors and forces which are operating, either for good or bad, upon the intricate relationships in which persons, communities, states and even nations live.

The most sensible and scientific manner in which this information can be gained is by way of the social survey, which, if done properly, is an accurate stock taking of conditions in a community, good, bad and neutral, as they actually exist. To take such an inventory will require the services of some sensible man or woman with a scientific bent of mind who can make a scientific study of the community and collect systematically all data bearing upon the life and well-being of the community. This data, however, can only be furnished by the people who comprise the community; thus is seen the absolute necessity of the harmonious co-operation on the part of these people with the person or persons who may be making the study for them and with them. And only to the extent that a harmonious co-operation exists and is exercised can the work result, in the fullest sense, in the fulfillment of its highest purpose, viz., to point out the way to a greater well-being for the people comprising the community, and also to lay the stepping-stones for a greater well-being for other communities. This is of course the highest and dual purpose of any justifiable undertaking, viz., that in the helping of oneself one helps others or points out to them a way to help themselves. Thus the community which is making such a scientific study of itself and its own conditions is not only setting the sign-posts to progress and the danger signals beside the pitfalls along the roadside and in the road-

bed that must be traveled on the way to self-improvement for itself alone, but also for other communities and even states and nations of which it is a component part . It is marking out and traveling the road to self-betterment and self-improvement, the only kind of improvement of which it may be justly proud. It is operating under a moral pride that has been harnessed up to carry out a civic need.

NOTE: Any one interested in copies of the questionnaire or survey blanks used by the college may secure such upon request to the Director of the Agricultural Experiment Station.

March, 1916

Circular No. 24

FERTILIZING LAWN AND GARDEN SOILS

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

AGRONOMY SECTION
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FERTILIZING LAWN AND GARDEN SOILS

BY PERCY E. BROWN

To make a good lawn or a productive garden, the soil must be reasonably fertile or be made so by special treatment, and it must be kept fertile by the regular use of manure or other suitable fertilizers.

At no time can more be done to insure a good soil for lawn or garden than when the excavating and grading are under way. Very often a site that is naturally fertile is made infertile by spreading over its surface the subsoil that is brought out of the basement excavation or moved in grading. Often, too, the building rubbish is scattered over the yard and covered thinly with subsoil. In either case, grass and vegetables grow feebly, the lawn is unsightly and the garden unprofitable. One of the first rules in making a lawn or garden, therefore, is to keep at least six to twelve inches of rich soil on the surface.

If it is necessary in grading to remove the original surface soil, which is likely to be fertile, save it; then remove a layer of the subsoil about a foot deep, haul it away, and put the surface soil back in its place to bring the yard to grade. If the soil taken from an excavation is to be used in filling a low spot, remove the surface soil from that spot first and later spread it over the subsoil that has been used for the fill. Remove all building rubbish from the yard before grading. Do not use it for filling unless the low spot is so large that the rubbish can be covered over with a good even layer of rich surface soil in which grass or vegetables will grow.

If these precautions were always taken to have the surface of the yard uniformly covered with a good rich soil many of the troubles with lawns and gardens would not arise.

Inasmuch as a rich surface soil is not always at hand, as difficulties of drainage and the like must be dealt with, and as the lawns or gardens already established are often not satisfactory, special methods must be followed to make soils productive. These methods must vary with different conditions, especially where lawns are concerned as it is clearly impossible to put organic materials into the soil under an established lawn; in such cases the methods must be adapted to the special problem.

It must be recognized furthermore that exactly the same methods of treatment will not fit all soil conditions. The recommendations of this circular are for average soil conditions; for special conditions the treatment must be modified, usually by varying the amounts of fertilizer used.

LAWNS.

The fertilization of lawns will be considered under three headings: Establishment, maintenance and renovation.

ESTABLISHING THE LAWN.

The successful establishment of a lawn depends upon, first, the careful preparation of the land; second, the proper fertilization of the soil, and third, the planting of grasses best suited to the locality and general soil and climatic conditions.

PREPARING THE SOIL.

The suggestion has already been made that the grounds around the house should be carefully graded after removing all building rubbish, that the subsoil should never be exposed at the surface and that a rich soil from 6 to 12 inches deep should cover the entire surface of lawn or garden. Several other things in preparing the soil are equally important.

In the first place, good drainage should be insured. To do that the laying of tile may be necessary. If the subsoil is very heavy and does not permit excess moisture to run off very readily, the surface soil is likely to hold too much water and become water-logged. Such a condition means a lack of air, and hence the beneficial processes that depend upon air cannot go on and there is an accumulation of injurious compounds which are harmful to grass. Tiling is necessary to remedy such a condition.

On the other hand, if the subsoil is light and sandy the water is lost too rapidly and the lawn will suffer in dry weather for lack of moisture. For such a condition the use of manures and lime will also often prove of much value.

In general it may be said that the subsoil should be moist at all times and yet permit of thorough drainage. It should hold enough moisture after the wet season to supply the lawn during dry weather.

In choosing the soil to cover places which have been filled in, secure a good loam, fairly rich in plant food and organic matter and free from objectionable weeds. Soil which has been under cultivation and has been giving satisfactory yields of ordinary farm crops is good, as its fertility has been proved and many objectionable weeds have been eliminated from it by the thorough cultivation to which it has been subjected. Soil for filling purposes should not be taken from cuts, steep hillsides or infertile areas overgrown with weeds, if it is to provide the surface soil for a lawn. It is almost impossible to obtain a good stand of grass on such soil.

After the yard has been properly graded and provided with good drainage and a good surface soil to a depth of at least 6 to 12 inches, plow up the entire area, turning over as much of the soil as possible without admixing any of the subsoil with the surface. Then it is ready for fertilization.

FERTILIZATION.

The foundation for fertilizing lawn soils is the use of manure, and enough must be used to provide an abundance of organic matter to keep the soil in the best condition for maintaining the lawn thru a long period of years.

The organic matter furnished by manure keeps the soils in the best condition for plant growth by increasing the waterholding power of light soils and by opening up heavy soils and putting them in better physical condition as regards both aeration and moisture. Manure also adds plant food and millions of bacteria, those microscopic organisms which are of so much importance in providing available food to plants. The proper decomposition processes cannot go on in soils and plant food cannot be produced in necessary amounts unless bacteria are present in abundance. The plant food added in the manure is only a small part of what will be necessary for the lawn for any long period of years and other fertilizers must be used also. But commercial fertilizers cannot take the place of manure in keeping the physical condition of the soil at the best, hence the necessity of a heavy application of manure when the soil is being prepared.

There is only one danger in the use of manure and that is the introduction of weed seeds which may prove very objectionable later. This danger may be overcome by the use of thoroly composted and rotted manure, for in the rotting process the weed seeds are killed.

The amount of manure to use in preparing a lawn will vary somewhat with the type of soil. On sandy soils the dressing can be made much heavier than on heavy soils. On average soil 40 to 60 loads per acre of well rotted stable manure is not too much. If the soil is very light and sandy more may satisfactorily be used. It is hardly possible to make the soil for a lawn too rich, and there is danger of its not being rich enough, so that abundant applications of manure should always be made.

In case stable manure is not available use dried manures, such as sheep manure. These may be secured from fertilizer companies, if not locally. Apply such materials at the rate of 1,000 lbs. per acre. They are not of as much value as well rotted stable manure, but they are not likely to contain weed seeds and they contain no litter and hence are somewhat more concentrated than stable manure.

If neither stable manure nor dried manure is available, the yard may be seeded to a green crop, such as clover, cowpeas or soy-beans, and after it has made abundant growth, it may be plowed under. This will add a considerable amount of organic matter to the soil and while the treatment is not as satisfactory as the use of well rotted stable manure, it is a valuable substitute for that material. One objection to this method is, of course, that it delays the securing of the lawn for

one season, but it is worth while to wait a year to insure a more permanent and satisfactory stand of grass.

After applying manures, determine whether the soil is acid or not.* If it is acid apply three to four tons of ground limestone per acre; this amount should prove sufficient for most soils in this state. It is possible, however, to apply lime in small amounts from time to time, provided finely ground limestone is used, and hence it is not necessary to make such a large initial application as in the case of manures, but enough should be used. Lime not only remedies acid conditions but also improves the structure of both heavy and light soils, opening up the former and making the latter more retentive of water and plant food. Lime also aids bacterial development and thus increases the production of available plant food, while it is itself a necessary food for the growth of most grasses.

To insure an abundance of plant food for the luxuriant growth of grass, applications of concentrated fertilizing materials in addition to manure and lime should be made. Phosphorus is the element most likely to be lacking from soils and this may be supplied in the form of bone meal, acid phosphate or rock phosphate. The former material is preferable and from 500 to 1,000 lbs. per acre should be used at first. Further amounts may be added later as necessary. Acid phosphate may be used if bone meal cannot be secured and a similar application made. If rock phosphate is employed, from 2,500 to 3,000 lbs. per acre must be applied as it becomes available very slowly. Even in the presence of abundance of organic matter supplied in the manure the production of available phosphorus from rock phosphate would be slow under a lawn and the use of bone meal or of acid phosphate is undoubtedly preferable.

In addition to phosphorous fertilizers, 300 to 500 lbs. of a high-grade commercial fertilizer should be applied per acre. Several brands of complete fertilizers may prove of value, a "3-6-8" or a "2-8-10" probably being the best; that is, complete fertilizers containing 3 percent nitrogen (NH_3), 6 percent phosphoric acid (P_2O_5), and 8 percent potash (K_2O), or containing 2 percent nitrogen (NH_3), 8 percent phosphoric acid (P_2O_5), and 10 percent potash (K_2O).

These complete fertilizers add enough available nitrogen, phosphorous and potassium to supply the needs of the young grass crop for its immediate growth, and stimulate the grass to an abundant early growth, giving it the start necessary to overcome the growth of weeds.

*The litmus paper test is convenient for testing soil as to its acidity. Secure blue litmus paper from any druggist. Take a small sample of soil, free from roots or grass, and put it in a clear glass tumbler. Insert two strips of the litmus paper in the soil so that they are half covered, being careful not to touch with the fingers that portion of the paper placed in the soil. Then add pure water carefully until the soil is thoroughly soaked. Let the test stand from 20 to 30 minutes, remove the paper and rinse thoroly. If the paper which was in contact with the soil has turned red then the soil is acid.

SEEDING.

In seeding choose grasses suitable for the locality. Kentucky blue grass makes the best turf. Canada blue grass is not as satisfactory. A mixture of blue grass and English or Italian rye grass gives the best immediate results. The English and Italian grass are quick growers and make a good temporary lawn, gradually dying out and leaving the blue grass in possession. Three parts of Kentucky blue grass to one of English rye grass is a mixture which has generally proven successful and is sown at the rate of 70 lbs. to the acre.

Special lawn mixtures which are sold for seeding shady places cannot be recommended. They do not give general satisfaction. If a lawn is to be established under trees with dense foliage, the only way to insure satisfaction is to trim the trees so as to admit sunshine.

Whatever mixture of grasses is sown, the seed should be pure seed and of high germination. The stand of grass is likely to be uneven and scant in parts of the yard if uncleaned, unselected seed containing a great number of hulls and light seeds is used. Selected or recleaned blue grass seed, although costing more than the poorer grades, will prove more economical in the long run.

The seed should be thoroughly distributed, preferably scattered half in one direction across the yard and the other half in the other direction. In this way, there is no possibility of bare spots or streaks.

It is desirable to sow grass seed just before a light shower. The rain pats the seed down close to the soil and insures a uniformly thick stand of grass. In Iowa the best time to seed a lawn is early in the spring, though in many seasons a very good stand can be secured by sowing about the middle of August, or just before the fall rains. Fall seeding, however, is quite uncertain on account of the unfavorable moisture conditions in the soil at that time of year. Furthermore, if the ground is not protected by snow during the winter and freezes and thaws repeatedly, the young grass plants from fall seeding are likely to be killed.

After the seed has been sown rake the surface of the soil carefully. If the ground is dry, it is advisable to roll also, but if showers have followed the seeding only the raking is necessary.

MAINTAINING THE LAWN.

After the lawn is established it must not be neglected or all the care used in its establishment will be wasted. It must be tended more carefully even than the farmer tends his crops, for it is expected to last for many years without being remade.

First, it is important that the grass should never be allowed to go to seed. Nothing else is so injurious to the maintenance of a luxuriant lawn as the production of seed. Keep the lawn mowed, just clipping the grass close enough to leave sufficient leaf area for the normal functioning of the plant. Only in periods of drought should mowing

be stopped and even then it is not well to allow any production of seed.

Mow the new lawn just as an old one, but set the mower high in order not to cut the plants back so far as to injure them. In the case of the new lawn it is well to allow considerable growth in the late fall to protect the grass roots during the winter.

Rolling is of considerable value on the new and also on the old lawn. The newly established lawn particularly needs frequent rolling to compact the soil and make the grass roots as firm as possible; the heavier the roller the better. On old lawns early spring rolling is essential to overcome the loosening of the grass roots due to winter's freezing and thawing. Frequent use of the roller during the entire season will also help to make the surface of the lawn more compact.

The use of water on lawns is frequently necessary during continued droughts, but under ordinary circumstances with average rainfall it is not necessary.

If the lawn is watered do not sprinkle it. Sprinkling does little more than to check the giving off of moisture by the leaves. It does not wet the ground except at the surface, from which the moisture is evaporated before it gets down to the grass roots. It is far better to lay the hose on the ground and allow the water to flow freely from it in one spot for an hour or more, and then move it to another spot. Such watering is not necessary every day even in the driest weather.

FERTILIZATION.

After the lawn is once established it can be fertilized only by surface applications. It must be emphasized again that no amount of later fertilization can remedy a lack of care in the preparation of the soil when the lawn is established. But after a good lawn is secured, its proper maintenance depends upon the addition of various materials to keep up the content or plant food.

Well rotted manure may be applied to lawns as a fall mulch, or during the winter, at the rate of 10 to 20 tons per acre. It protects the soil from the alternate freezing and thawing of the winter and also adds valuable plant food which is leached out of the manure and into the soil by the winter rains. Only rotted manure should be used for such a purpose as the danger from weed seeds in fresh manure is very great. The manure may be left on the lawn until the grass begins to grow in the spring when it should be raked off and the lawn thoroughly rolled. In case rotted stable manure is not available, dried sheep manure may be applied at the rate of one-half to one ton per acre. The best effects from this material would probably be secured by its use in the early spring, although it may also be applied in the fall. The objection to the spring application is that it mars the appearance of the lawn.

As a spring top dressing, apply finely ground bone meal at the rate of 500 to 1,000 lbs. per acre. Phosphorus may also be applied in the

form of acid phosphate, but the bone meal is preferable. Potassium may be applied as wood ashes or as commercial muriate of potash, but it is usually preferable to use a complete fertilizer such as was recommended in the establishment of the lawn, that is, a "3-6-8" or "2-8-10" brand, instead of a special potassium fertilizer. If this is applied at the rate of 300 to 500 lbs. per acre one year and then the ground bone for two years, sufficient phosphorus and potassium will be added to keep the grass supplied with these elements.

Nitrate of soda should be applied at the rate of 200 lbs. per acre in the spring after active growth has begun. This may be added by dissolving in water and sprinkling over the lawn, or by spreading it over the grass just prior to a rain or a sprinkling. The complete fertilizer and bone meal should also be applied at a time when it promises to rain in order that they may be washed down into the soil.

Further applications of nitrate of soda may be made to the lawn during the summer with advantage. Fifty pounds per acre applied several times during the season will keep the grass green and rank during the hot summer months when nitrification in the soil is low and the grass is apt to become parched and yellow.

Lime should be applied to lawns only very infrequently. If a liberal application, such as has been recommended, is made when the lawn is established it should not be necessary to apply more lime within five or six years. If the soil has a tendency to become acid, however, it will be well at the expiration of that time to apply finely ground limestone in the fall at the rate of 500 to 1,000 lbs. per acre. This operation should be repeated every five or six years and the reaction of the soil will then be kept satisfactory.

The use of well rotted stable manure, or of dried sheep manure, the application of finely ground bone meal for two years and a complete fertilizer every third year, a spring and summer application of nitrate of soda and the use of lime every fifth year, should together keep a lawn covered with a vigorous, luxuriant growth of grass.

Proper mowing and rolling are also to be emphasized as important in the maintenance of a fine greensward.

RENOVATING THE LAWN.

The most effective way to renovate the old lawn is to make a new one. In most cases it will not pay to attempt to patch a poor grass plot for the difficulty probably is due to lack of proper soil conditions and these cannot be satisfactorily remedied without an entire remaking of the lawn.

If the lawn is on a good soil and is merely disfigured with weeds, it can be brought into satisfactory condition by scratching the surface with a rake after removing the weeds and seeding with good cleaned seed, using about one-half as much as for a new seeding. Bone meal, a complete commercial fertilizer and nitrate of soda may then be

added as recommended in the discussion of the maintenance of lawns.

But usually a poor lawn is due to originally poor soil conditions and these can only be remedied by a new start. It is best to plow up the lawn, apply lime and manure, bone meal and commercial fertilizer as recommended in the establishment of lawns; seed with good grass seed, roll and keep mowed and fertilized and a new lawn may be secured which will prove very satisfactory.

This is the quickest and surest method of securing a good stand of grass and a uniform lawn. Patching a lawn is a tedious process at the best and the result is almost certain to be anything but satisfactory.

VEGETABLE GARDENS.

Most of the difficulty in growing good vegetables is due to the fact that the soil is not properly prepared. Either the garden is made on poor subsoil thrown out in the building excavations, or the soil is not properly fertilized.

The soil should be just as carefully prepared for the establishment of a vegetable garden as for the establishment of a lawn, the only difference being that applications of fertilizing materials may be made annually to a garden soil and hence smaller initial amounts are required.

All vegetables require an abundance of plant food for their best growth. Available plant food is not produced rapidly enough even in the best type of soil, to supply the needs of rapidly growing vegetables. Furthermore, for early spring crops the bacterial processes in the soil at that time of year are too slow to feed the plants properly. The necessity for special fertilization of gardens is, therefore, easily understood.

The fertilizing methods used in ordinary farming will not do for the garden. Concentrated commercial fertilizers, supplying several kinds of available plant food, must be used for the garden. There is considerable variation in the fertilizer requirements of different garden crops but these cannot be discussed individually here. Furthermore, home gardens grow a large variety of crops in small quantities and for them it would be quite impossible to follow special methods of treatment for individual crops. The case is different in market gardening, of course, but it is the intention to consider here only the home garden. The recommendations will, therefore, be made general to suit the needs of the common vegetables which make up the ordinary garden.

Certain special fertilizing mixtures are suitable for a large variety of crops and are good as a general basis for fertilizing gardens. For the small garden some complete brand of fertilizer ready for use is cheaper than incomplete brands suitable for the different crops. The home mixing of small amounts of incomplete fertilizers for use on gardens is troublesome and unnecessary. Complete brands quite as suitable for general garden crops may be purchased ready for use.

PREPARATION OF THE SOIL.

As in the case of lawns, gardens should not be made on areas from which the surface soil has been removed or which have been filled in with subsoil or building rubbish. For a successful garden it is essential that there be a covering of surface soil at least 12 inches deep. If this is not the case, surface soil must be secured and spread over the area if a satisfactory growth of vegetables is to be insured.

It is quite essential also for gardens that the drainage be satisfactory. Vegetables will not do well in a soil which is wet and consequently cold. In choosing the location for the garden, select a southern exposure if possible, as this is most desirable. Soil on a southern slope is easily worked, allows of the perfect control of the water which falls upon it and, what is more important than either of these points, it permits of earlier spring working. Frequently it is possible to grow two crops on a southern slope where only one could be grown on a northern slope. Then, too, certain crops, such as melons and tomatoes, which require a long season and a warm location to mature, might not ripen on a northern slope. For early spring crops it is necessary that the soil be light and sandy; warming up quickly under the influence of the spring sun. Such a soil on a southern slope presents ideal conditions for early vegetables. In most cases, however, there is little opportunity for choice in the location of the garden and the soil must be used as it is found and put in the best condition possible for the growth of vegetables.

If the soil is heavy and has a tendency to be too wet, install tile drains or many vegetables will suffer from an over supply of moisture and consequent delayed growth.

A good loam surface soil underlaid by a rather stiff, clayey subsoil will present ideal conditions for gardens. On such soils enough water is retained in the subsoil for the nourishment of the crop, but it is also porous enough to permit of proper drainage and the surface soil will not retain an over supply of water.

If the subsoil and surface soil are both light and open in texture, they may not hold enough moisture to keep the crop supplied. In such cases cultivation, whenever practicable, will be of much assistance in preventing the rapid loss of water which may occur by evaporation. A good mulch on the surface of light soils will help them to hold as much as 30 percent more water than the same soil uncultivated. With some crops, of course, such cultivation is not possible, but it should be practiced on light soils whenever feasible.

Applications of manure will also assist in keeping up the moisture content of light soils. The organic matter supplied makes the soils less porous and open and makes the percolation and drainage less rapid. The application of lime to such soils is also of value in making them less porous. Lime is also of value in opening up heavy soils and making them less retentive of moisture.

FERTILIZATION.

Just as in the case of lawns, the basis upon which the fertilization of gardens rests is the use of stable manure. This is the best material for maintaining the humus content of the soil. The importance of humus in both light and heavy soils has been discussed. The relation of organic matter to the moisture content, to the amount of air present, to the decomposition processes in the soil, and hence to the production of available plant food has been pointed out. No other material accomplishes quite as much as manure along these lines.

In preparing for the garden, therefore, a liberal application of manure should be made. The actual amount may vary considerably, but at least 25 tons per acre should be applied and if the soil is very light in texture even a larger amount may be used.

Manure adds some plant food to the soil, but its value from this standpoint is secondary to its value in improving the physical condition of the soil. Plant food may be added by the use of commercial fertilizers, but such substances are of no value in keeping soils in the best physical condition. When large amounts of manure are used, however, the plant food introduced becomes of importance and smaller amounts of commercial fertilizers are necessary to keep up the plant food content of the soil.

Well rotted manure has been found to be preferable to the fresh material. Fresh manure is not quick enough in its action to give the best effects in the soil. Its coarseness prevents its thorough incorporation with the soil particles and hence its valuable influence is lessened. Again, fresh manure is likely to cause a rank growth of such crops as tomatoes, egg plants, peppers, melons and cucumbers, at the sacrifice of the fruit. With root crops, like radishes, turnips, beets and carrots, fresh manure not only causes excessive growth of tops but also prevents the best root development. Furthermore, fresh manure is apt to carry objectionable weed seeds which will prove troublesome in the garden. Rotted manure should, therefore, always be used when available.

In many cases rotted stable manure is not available for use on garden soils and some other material must be substituted. Dried animal manures, such as sheep manure, may serve in such instances just as was suggested with lawn soils. An application of such materials at the rate of 2 to 3 tons per acre should be made. The concentration of plant food in dried animal manures is much greater than in stable manure but their value for their effect on the physical condition of the soil is very much less. They prove, however, a valuable substitute for stable manure.

Green manure crops are frequently used to advantage to supply humus to the soil in case rotted stable manure is not available. Such a means of improving the physical condition is particularly important on light sandy soils deficient in organic matter. Clover, cowpeas, soybeans or other legumes may serve for the green manure crop.

Leguminous crops are preferable to non-legumes for green manures because of the nitrogen which they add when well inoculated. When such crops are grown for green manuring purposes they should be turned under in the soil before they become mature so that the decomposition processes proceed properly. If the crop has matured and consists, therefore, largely of crude fibre, its decomposition will occur very slowly and much of the value from its use will be lost.

The objection to the use of leguminous green manure crops as humus formers is that the establishment of the garden must be delayed for a season, but where the soil is poor in humus and stable manure or dried manures are not available, it is the only means of preparing the soil to produce satisfactory crops. Frequently green manuring may be practiced in gardens after their establishment by introducing suitable green manure crops into the rotation preceding the regular garden crops.

One precaution should always be observed in turning under crops for green manures and that is that the moisture conditions are satisfactory in the soil. If a heavy crop is turned under in a dry soil or during hot dry weather, the subsequent crop may suffer for lack of moisture.

When the humus content of garden soils has been insured by the use of rotted stable manure, dried animal manure or green manure, test the soil for acidity. If it is acid, apply lime. Three to three and one-half tons of ground limestone per acre is an average application for Iowa soils that are acid and will usually prove ample to put the soil in the best condition for vegetables. Many vegetables are quite sensitive to acidity; others are less affected by acid conditions, but practically all are favored to a greater or less degree by the presence of an abundance of lime in the soil.

Vegetables require an abundance of available plant food and hence it is necessary to apply some concentrated commercial fertilizer to gardens in addition to the rotted stable manure, dried manure, or green manure. These latter materials supply some plant food, but their main value is due to the organic matter they add to the soil and the plant food introduced is not enough to meet the needs of the rapidly growing vegetables.

Several brands of complete fertilizers are on the market which have proven quite satisfactory for gardens. Among these may be mentioned a "3-8-5" brand and a "3½-8-4" brand especially prepared for vegetables. Either of these materials applied to the garden soil at the rate of 500 to 1,000 lbs. per acre should prove of much value, supplying as they do considerable quantities of all the essential plant food constituents in a readily available form. If the soil is very light in texture and poor in plant food, 1,000 to 2,000 lbs. per acre should be supplied.

Such complete fertilizers may be used from year to year on garden

soils but manure should also be used or the soil will soon become deficient in humus and fail to grow good crops in spite of the presence of abundance of plant food.

Sodium nitrate is often used to great advantage on gardens. Applications at the rate of 200 lbs. per acre in addition to other fertilizing materials are of particular value on early crops such as lettuce, radishes, early peas, and early cabbage.

For potatoes use special potassium fertilizers. Applications of the muriate of sulfate of potash at the rate of 600 lbs. per acre, in addition to the complete fertilizer brands already mentioned, have been found to be of value. Where potatoes are to be grown, therefore, it will be well to substitute a complete brand of fertilizer containing more potassium for the special brands which have been suggested. Thus, instead of a "3-8-5" brand, a "2-8-10" or a "4-8-10" brand will be found to be of superior value for potatoes.

These same fertilizers may be used from year to year on the garden soils and if the organic matter or humus content of the soils is kept up by the use of well-rotted stable manure or green manures, the soil will be in the best condition for the growth of vegetables.

SEEDING.

The best seed should be used, for poor seed will not give good yields even on the very best of soil. It pays to procure select seed even at a greater expense. The varieties of vegetables should be chosen to allow of the greatest range of seasonal growth. Early, medium, and late varieties may be chosen and planted in succession, thus insuring an almost continuous yield of certain desired crops.

Some crops should be started in hotbeds or cold frames and later transplanted to the garden when the season is far enough along to allow of their satisfactory growth. Others which are hardier, such as lettuce, radishes, beets and parsnips, may be seeded early enough in the garden soil.

In arranging the garden, each crop should be allowed enough space for its proper development. It is well also to group all long season and perennial crops together. The short season crops are soon out of the way and may be followed by a succession of crops if they are planted in adjoining rows.

It is desirable further to rotate the crops in the garden as far as feasible for several reasons. In the first place, such crops as onions are especially liable to insect injuries if grown in the same place successively. Injuries from fungus diseases such as potato scab, beet scab, onion and melon rust, corn smut, and other diseases, are much less likely to occur when the crops are not grown repeatedly on the same soil.

Then too, the plant food in the soil may be utilized to the best

advantage if the crops are varied, for different crops use varying amounts of plant food in their growth. By changing the location of garden crops from year to year the best results are secured.

After the garden is established its thorough cultivation as far as the crop grown will **permit is** important. Cultivation not only rids the ground of weeds but, more important, it maintains a mulch on the surface and that means the better maintenance of moisture conditions in the soil. By thorough cultivation the water content of the soil is kept up to a greater percent and the crops are better able to withstand droughts which are so apt to occur.

In some seasons it may be necessary to apply water to gardens. This should not be done unless the crop is suffering and if it is done certain precautions should be observed. It is not advisable to apply more than enough water to moisten the land. The soil should not be water-soaked. The best plan is to arrange to wet the roots of the plants and avoid getting water on the leaves, as in this way less of the water used is wasted. Finally, after the water is applied, if the land will permit of it, the soil should be cultivated thoroughly so that it will not bake. Evaporation will then be prevented and the water applied will be saved in the soil.

Facts About So-Called Hog Cholera Cures and Specifics

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Facts About So-Called Hog Cholera Cures and Specifics

By C. H. Stange and C. G. Cole.

Although many so-called hog cholera cures and specifics are widely advertised, none has been found so far in the tests made by the veterinary section of the Iowa Agricultural Experiment Station which will cure hogs affected with cholera. Furthermore, the only product known at the present time which will immunize hogs against cholera is the anti-hog cholera serum produced by the Niles-Dorset method.

Included in the tests of alleged hog cholera cures and specifics so far completed by the veterinary section and the state bacteriological laboratory in cooperation are the following:

Cholera Immune U. S. Specific

American Specific No. 2

Co-Vac-O

No. 544 Curative

No. 544 Immunizing

De Vaux Cholera Antitoxin

Dr. D. W. Nolan's Anti-Hog Cholera Specific (Noxine)

In addition tests of the Niles-Dorset hog cholera serum were made simultaneously with each of the above products.

These tests were undertaken because of numerous inquiries concerning the efficiency of various so-called hog cholera cures and specifics. These requests for information were so urgent that they made it clearly necessary to determine the reliability of such preparations by means of practical tests conducted under conditions as nearly as possible like those existing on the farms of Iowa. These so-called cures always meet with more or less sale because in cases of distress persons are inclined to take up with the mysterious and buy some new discovery promoted by an unknown person who has little or no responsibility. Particularly do they find a ready market in connection with such epidemics as the so-called Kansas horse disease, the foot and mouth disease, and hog cholera. At these times some previously little known person appears suddenly as a "scientist" and announces his discovery of some specific or cure for the animal disease which happens to be raging. This newly discovered "remedy" is sold to many innocent purchasers who sooner or later learn that they are victims and have parted with their money while the animal disease has followed its natural course uninfluenced by the treatment with the so-called cures.

This sort of practice has been carried on for half a century. Records show that as early as 1862 what were then called "infallible preventatives and sure cures" were used with the same ineffectiveness as at the present time. This class of "remedies" is usually accompanied by many testimonials which are used as strong arguments to recommend them. It should be borne in mind that reliable remedies do not require such testimonials. It should also be remembered that no great discoveries of this character have been made outside the laboratories regularly equipped for, and recognized by state and national government as doing reliable research work. If live stock purchasers would remember that they have competent representatives in the department of agriculture at Washington and at the various state experiment stations who are glad to give them all the information they can along these lines and that this information will be reliable, they would save themselves much trouble and money.

METHOD OF CONDUCTING TESTS

In conducting the tests that were made of the various so-called remedies and of anti-hog cholera serum, special effort was made to be fair and impartial to all concerns. The only object was to learn whether or not the products tested possessed any curative or immunizing powers against hog cholera. It is realized that the present method of producing anti-hog cholera serum is very expensive, because it necessitates the construction of expensive sanitary buildings and the killing of thousands of young shoats to make a virus with which to produce hyper-immune hogs. Therefore, the experiment station and state bacteriological laboratory are not opposed to a more simple and economical method of combating hog cholera. Such a method will be welcomed when it appears. Up to the present time, however, no product has been found that will cure hogs affected with cholera and the only product so far as known that will immunize the hog against cholera is the Niles-Dorset anti-hog cholera serum.

For the sake of thorough comparison, a test was made of anti-hog cholera serum at the same time each of the other preparations was tested. Pigs that received the serum were placed in the pens with the ones receiving the other cures or specifics, except in the case of the De Vaux Vaccine, the pigs in this test being kept separately. Great care was exercised in selecting the pigs for these tests. They were taken from three farms which were known to be free from cholera infection. The pigs were free from parasites and in the very best of physical condition. They were brought to the pens at the experiment station in wagons and treated immediately so as to avoid any previous exposure to hog cholera.

In testing No.544 which is claimed to be both a curative and an immunizing agent we used three healthy pigs for the immunizing dose and three sick pigs for the curative dose. The sick pigs selected

were in the early stage of the disease as they were known to be eating and appearing healthy up to January 25, 1915, the day before the tests were made.

The pen used for the above tests was clean and well ventilated. The pigs received the best of care and feed.

The tests of Co-Vac-O, Hog Cholera Immune and Hog Cholera No. 2 were started on January 12, 1915, while the tests for No. 544 and Anti-hog cholera serum were started on January 26, 1915, the pigs being placed in the same pen with the other tests.

Virus was administered to the pigs receiving anti-hog cholera serum and the two check pigs only, the other pigs receiving their exposure from contact with sick pigs in the same pen. The doses administered were exactly as recommended by the manufacturers of the various products.

Careful post mortem examinations were held over all pigs that died.

RESULTS OF THE TESTS

Following is a detailed report of the tests and the results obtained:

TEST OF CHOLERA IMMUNE U. S. SPECIFIC

Manufactured by The U. S. Specific Co., Indianapolis, Ind.

Date of test—January 12, 1915.

No. of Pig	Weight	Dose of Remedy	Results of Exposure to Hog Cholera
1713	58 lbs.	5 cc	Died of Hog Cholera Feb. 6, 1915
1714	49 lbs.	4 cc	Died of Hog Cholera Feb. 11, 1915
1715	50 lbs.	4 cc	Died of Hog Cholera Feb. 3, 1915
1716	51 lbs.	5 cc	Died of Hog Cholera Feb. 2, 1915
1717	43 lbs.	4 cc	Died of Hog Cholera Feb. 12, 1915
1718	42 lbs.	4 cc	Died of Hog Cholera Jan. 30, 1915

TEST OF AMERICAN SPECIFIC No. 2

Manufactured by The American Specific Co., Indiana Harbor, Ind.

Date of test—January 12, 1915.

No. of Pig	Weight	Dose of Remedy	Results of Exposure to Hog Cholera
1719	52 lbs.	5 cc	Died of Hog Cholera Feb. 16, 1915
1720	36 lbs.	3 cc	Died of Hog Cholera Jan. 31, 1915
1721	50 lbs.	4 cc	Died of Hog Cholera Jan. 30, 1915
1722	42 lbs.	4 cc	Died of Hog Cholera Feb. 15, 1915
1723	50 lbs.	4 cc	Died of Hog Cholera Jan. 30, 1915
1724	53 lbs.	5 cc	Died of Hog Cholera Feb. 1, 1915

TEST OF CO-VAC-O

Manufactured by Co-Vac-O Company, Indianapolis, Ind.

Date of test—January 12, 1915.

No. of Pig	Weight	Dose of Remedy	Results of Exposure to Hog Cholera
1725	46 lbs.	4 cc	Died of Hog Cholera Feb. 13, 1915
1726	50 lbs.	4 cc	Died of Hog Cholera Jan. 31, 1915
1727	43 lbs.	4 cc	Died of Hog Cholera Feb. 5, 1915
1728	56 lbs.	4 ½ cc	Died of Hog Cholera Jan. 29, 1915
1729	46 lbs.	4 cc	Died of Hog Cholera Feb. 4, 1915
1730	44 lbs.	4 cc	Died of Hog Cholera Feb. 20, 1915

1731	No treatment	} Used as checks— Killed for virus Jan. 29, 1915.
1732	No treatment	
1733	No treatment	
1734	No treatment	

TEST OF No. 544 CURATIVE

Manufactured by The Thiele Laboratories Co., Columbus, Ohio.

Date of test—January 25, 1915.

No. of Pig	Weight	Dose of Remedy	Results of Exposure to Hog Cholera
1740	52 lbs.	7 ½ cc	Died of Hog Cholera Feb. 11, 1915
1741	70 lbs.	7 ½ cc	Died of Hog Cholera Feb. 6, 1915
1742	70 lbs.	7 ½ cc	Died of Hog Cholera Feb. 1, 1915

TEST OF No. 544 IMMUNIZING

Manufactured by The Thiele Laboratories Co., Columbus, Ohio.

Date of test—January 26, 1915.

No. of Pig	Weight	Dose of Remedy	Results of Exposure to Hog Cholera
1743	45 lbs.	4 cc	Died of Hog Cholera Feb. 7, 1915
1744	62 lbs.	4 cc	Died of Hog Cholera Feb. 15, 1915
1745	60 lbs.	4 cc	Died of Hog Cholera Feb. 8, 1915

TEST OF S. B. L. No. 75 ANTI-HOG CHOLERA SERUM

Date of test—January 26, 1915.

No. of Pig	Weight of Pig	Am't of Virus	Am't of Serum	Results
1749	50 lbs.	2 cc	20 cc	Pigs remained well
1750	45 lbs.	2 cc	15 cc	Pigs remained well
1751	55 lbs.	2 cc	20 cc	Pigs remained well
1752	52 lbs.	2 cc	15 cc	Pigs remained well
1753	65 lbs.	2 cc	25 cc	Pigs remained well
1754	60 lbs.	2 cc	25 cc	Pigs remained well
1755	50 lbs.	2 cc	0	Died of Hog Cholera Feb. 3, 1915
1756	50 lbs.	2 cc	0	Killed for Virus Feb. 3, 1915

TEST OF DeVAUX CHOLERA ANTITOXIN

Manufactured by DeVaux Antitoxin Co., Chicago, Ill.

Date of test—January 12, 1915.

No. of Pig	Weight of pig	Dose of Remedy	Dates of doses	Results
1735	55 lbs.	4 cc	In each case, 1st dose 1-12-15 2nd dose 1-13-15 4rd dose 1-19-15	Died Feb. 3, 1915 Cholera
1736	54 lbs.	4 cc		Died Feb. 13, 1915 Cholera
1737	52 lbs.	4 cc		Died Jan. 28, 1915, Cholera
1738	49 lbs.	4 cc		Died Feb. 10, 1915 Cholera
1739	50 lbs.	4 cc		Died Jan. 30, 1915 Cholera

Where immunization is desired the manufacturer of this product recommends the administration of four doses, to be given as follows: One on the first day, one on the second, one on the seventh and one on the twenty-first.

We attempted to isolate the pigs used in this test so as to keep them from exposure to cholera until after the fourth dose was administered but shortly after the third dose was administered on January 19, 1915, the pigs sickened, so the fourth dose was not given. Pigs all died of cholera on the dates given above.

While this test is incomplete it shows the impracticability of a method of immunizing hogs which requires three weeks' time to complete, especially in districts where cholera is prevalent.

TEST OF Dr. D. W. NOLAN'S ANTI-HOG CHOLERA SPECIFIC (Later called Noxine)

Manufactured by Dr. D. W. Nolan's Specific Co.

Date of test—April 7, 1915.

No. of Pig	Weight of pig	Dose	Exposure	Results
1798	50 lbs.	As per directions in each case	Pen with sick pigs in each case	Died May 3, 1915
1799	60 lbs.			Died April 26, 1915
1800	40 lbs.			Died April 1, 1915
1801	50 lbs.			Died April 19, 1915
1802	55 lbs.			Died April 22, 1915

On April 6, 1915, 37 healthy pigs were purchased from farmers whose premises were known to be free from hog cholera infection.

Thirty-two of these pigs were used in testing four mixtures of serum and five were selected for the purpose of testing the curative value of Dr. Nolan's Specific, a product which is represented to be both a curative and a preventative for hog cholera.

These five pigs were weighed, numbered and placed in a pen with two sick pigs. They were not injected with virus.

Pigs remained well and ate heartily until April 15 when pigs

Nos. 1801 and 1802 did not come up to eat. The other three pigs, Nos. 1798, 1799 and 1800, were still eating and appeared healthy.

Dr. Nolan's remedy was administered as directed to all five of the pigs, beginning on April 15 the first day that sickness appeared.

Pasteurized milk was purchased from the dairy department of Iowa State College in which the medicine was placed and fed from an iron trough. Each pig was given two teaspoonsful of the medicine in a pint of milk each morning and evening. A bran slop was given at noon.

The above is as directed by the producers of the medicine.

During this period, from April 15 to April 22, two pigs died of hog cholera. Number 1801 died on April 19 and 1802 died on April 22, 1915.

On April 24 the remaining three pigs would not drink the milk and medicine so the medicine was administered with a spoon each morning and evening until they were all dead of hog cholera.

Number 1799 died on April 26, No. 1800 died on May 1 and No. 1798 died on May 3.

Post mortem examinations revealed well marked lesions of hog cholera in each carcass.

SUMMARY

Products tested:

Cholera Immune U. S. Specific.

American Specific No. 2.

Co-Vac-O.

No. 544 Curative.

No. 544 Immunizing.

De Vaux Cholera Antitoxin.

Dr. D. W. Nolan's Anti-Hog Cholera Specific (Noxine).

Hog Cholera Serum. (Niles-Dorset).

No. of shoats used in test46

No. of shoats treated40

No. of shoats not treated 6 All died

No. of shoats treated with hog cholera serum 6 None died

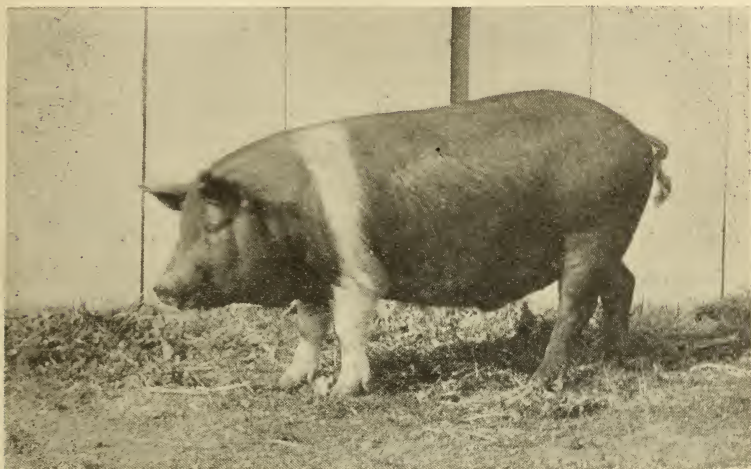
No. of shoats treated with other products not serum ..34 All died

Method of Exposure: Infected pen. Serum test pigs given 2 cc virus in addition to pen exposure.

The results of tests in Ohio, Indiana and Kentucky on "544" gave the same results as were secured in the Iowa tests.

All above tests indicate that none of the products entering into the tests protected hogs against attacks of hog cholera except hog cholera serum prepared according to the general plan worked out and recommended by the Bureau of Animal Industry of the U. S. Department of Agriculture.

SUCCESSFUL SWINE RATIONS FOR THE CORNBELT



He ate all the corn he wanted in dry lot, but it was properly supplemented.

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IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

ANIMAL HUSBANDRY SECTION

AMES, IOWA

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SUCCESSFUL SWINE RATIONS FOR THE CORN BELT

By John M. Evvard and W. H. Pew

"Just how much of protein and mineral supplements should be fed with corn to swine of various sizes, ages, and classes" is the big question which this circular considers.

Up-to-date practice is reflected in the rations presented; furthermore, these rations have been tested in actual practical feeding trials under the experimental supervision of the animal husbandry section of the Iowa Agricultural Experiment station.

The amount of concentrated supplements, such as skim-milk, tankage, linseed oil meal, wheat middlings, and others, to feed depends to a very large extent upon whether or not the swine are in dry lot or on high or low protein yielding forages or pastures.

It is quite evident in practice that corn fed swine running in high protein pastures, such as alfalfa or rape, require a minimum of protein and mineral supplement such as skim-milk or tankage; whereas those fed in dry lot or on low protein pastures, such as sorghum and dry bluegrass, demand the maximum. Unfortunately, for about 6 months of the year or from the middle of November to the middle of April, Iowa farmers are compelled by necessity to feed in dry lot because of the absence of green pasturage, due to climate.

To meet practical conditions, the amount of protein and mineral supplements to feed along with corn, are given, both for dry lot and for different pasturage.

DRY LOT FEEDS AND FEEDING

Pigs, as they grow from suckling to marketing days in "greenless" fields and bare lots, secure but little of organic nourishment in addition to that supplied in the feeds allowed by the herdsman. The dry-lot-corn-fed pig does not have the chance of balancing his ration as does the alfalfa-pasture-corn-fed pig, and its comparative requirement for high priced supplemental feeds stands out strikingly.

One little realizes that small, young, weanling pigs, which do best in dry lot on a ration of about 25 pounds tankage to 100 pounds of corn, do equally well on only 5 pounds of the same tankage to 100 pounds of corn on alfalfa pasture, because the pigs eat enough of the high protein and mineral carrying alfalfa to make up the de-

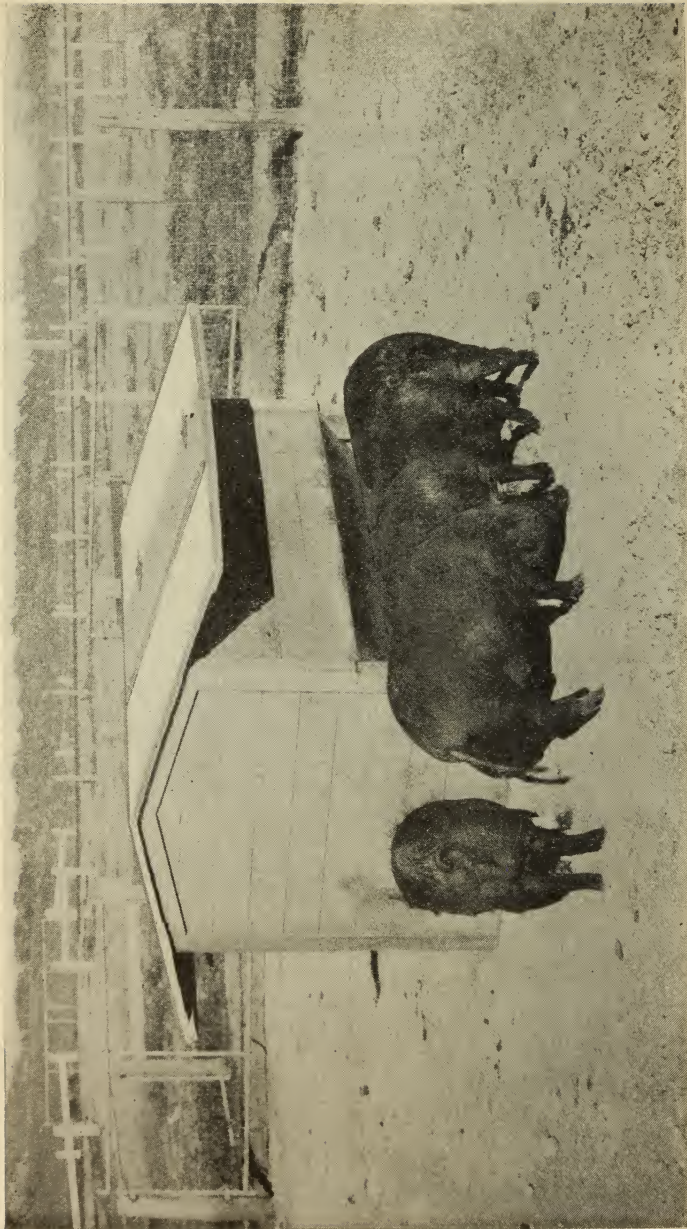


Fig. 1. THE IOWA SELF-FEEDER IN THE FATTENING YARDS
These dry lot self-fed pigs in the absence of pasture have done well on the economical "Free-Choice" Iowa dry feeding ration of shelled corn, wheat middlings, 60% protein tankage, bone meal, charcoal, and rock salt allowed in separate feeders at free-will.

iciency,—equivalent to the 20 pounds of tankage. It is quite difficult to believe that the pig has eaten sufficient of cheaply produced alfalfa, harvesting it himself, so that it will not require so much supplemental feed, but this represents the facts and emphasizes two very definite propositions:

TWO IMPORTANT FEEDING PRINCIPLES

1. *The great necessity for a liberal allowance of supplemental proteins and minerals along with corn in dry lot feeding in order that the pig may "grow to the limit" equally as well as if he is fed corn on alfalfa or rape or other good forage.*

2. *The great practical saving in feed purchase money otherwise necessary for the laying in of concentrated supplemental feeds because of the forage,—alfalfa, rape, and others. The forage field is the economical place to grow the pig profitably. In Iowa corn is the most efficient grain to feed with the forage in order to grow and fatten pigs with most profit.*

SUCCESSFUL RATIONS FOR ECONOMICAL DRY LOT FEEDING

I. FATTENING AND GROWING HOGS FOR MARKET.

1. Suckling Pigs,—5 to 40 pounds (fed in creep).
 - A. Corn 80, tankage 20, salt.*
 - B. Corn 75, middlings 10, tankage 15, salt.
 - C. Corn self-fed, tankage self-fed, salt.
 - D. Corn self-fed, middlings self-fed, tankage self-fed, salt.
2. Weanling Pigs,—30 to 100 pounds.
 - A. Corn 80 to 85, tankage 20 to 15, salt.
 - B. Corn 75 to 80, middlings 10, tankage 15 to 10, salt.
 - C. Corn self-fed, tankage self-fed, salt.
 - D. Corn self-fed, middlings self-fed, tankage self-fed, salt.
3. Shotes,—100 to 175 pounds.
 - A. Corn 85 to 90, tankage 15 to 10, salt.
 - B. Corn 75 to 80, middlings 15 to 10, tankage 10, salt.
 - C. Corn self-fed, tankage self-fed, salt.
 - D. Corn self-fed, wheat middlings self-fed, tankage self-fed, salt.
4. Hogs,—175 to 250 pounds.
 - A. Corn 92 to 96, tankage 8 to 4, salt.
 - B. Corn self-fed, tankage self-fed, salt.
5. Fat Hogs,—250 to 350 pounds.
 - A. Corn 95 to 99, tankage 5 to 1.
 - B. Corn self-fed, tankage self-fed, salt, and charcoal.

*All rations given on basis of pounds (or parts by weight) in a hundred total. The salt is to be allowed preferably at free will, as is the charcoal when mentioned.

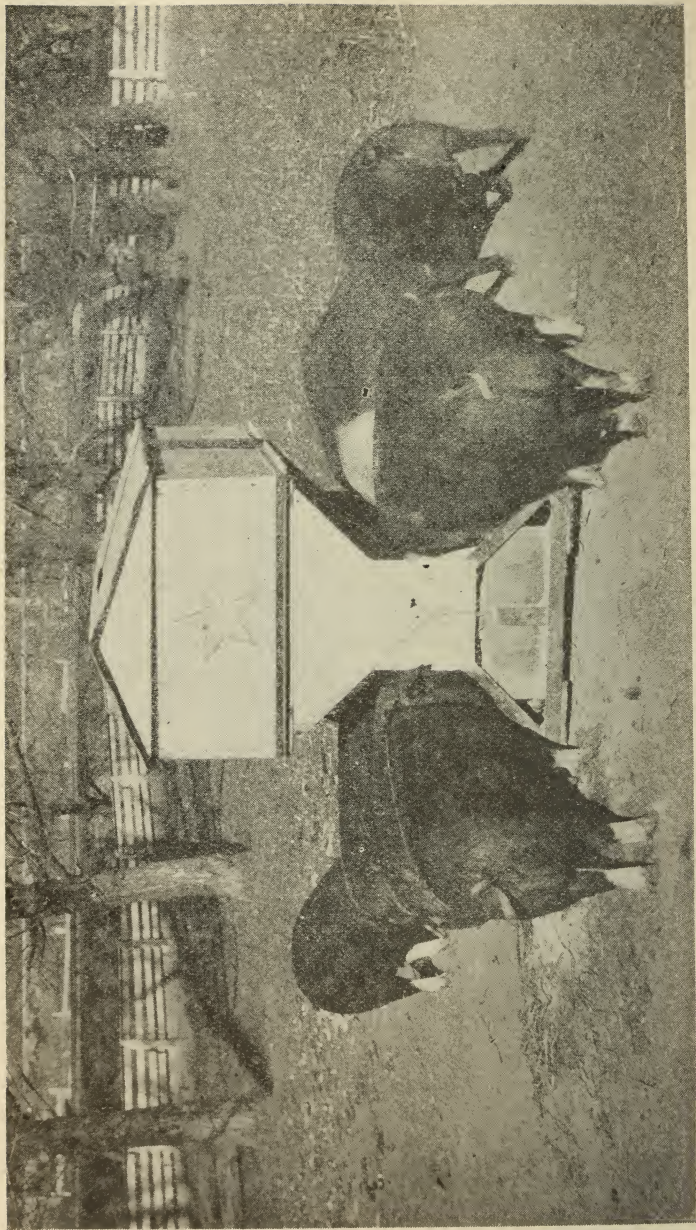


Fig. 2. SELF-FED GILTS DEVELOPING INTO PROFITABLE BREEDING STOCK

These pure bred gilts have an abundance of size for their age. They were self-fed for a considerable time. A good plan to avoid overfattening is to mix ground alfalfa, preferably, or ground oats or wheat bran, with the grain feeds but allow the tankage straight. The tankage can be so mixed if they tend to overeat of it, to the extent of half a pound per head daily. The self-feeder is useful not only in fattening but in preparing for breeding.

II. FATTENING SOWS FOR MARKET.

1. Yearling Sows (Gilts) After Weaning, "Fattening off".
 - A. In Poor Condition, and "Run Down".
 1. Corn 90, tankage 10, salt and charcoal.
 2. Corn self-fed, tankage self-fed, salt and charcoal.

Omit tankage last two or three weeks.
 - B. In Good Condition—Thrifty.
 1. Corn 92 to 95, tankage 8 to 5, salt and charcoal.
 2. Corn self-fed, tankage self-fed, salt and charcoal.

Omit tankage last two or three weeks.
2. Two-year Old or Older Sows after Weaning, "Fattening off".
 - A. In Poor Condition, and "Run Down".
 1. Corn 95, tankage 5, salt.
 2. Corn self-fed, tankage self-fed, salt.

Omit tankage last few weeks.
 - B. In Good Condition—Thrifty.
 1. Corn all will eat, preferably self-fed, salt.

III. FATTENING STAGS FOR MARKET.

Stags may be fed about same as sows.

IV. BREEDING SOWS, CARRYING (PREGNANT).

1. At Breeding Time—Flushing to Increase the Number in Litter.

Start 10 days before breeding.

 - A. Gilts.
 1. Corn self-fed, tankage self-fed, salt.
(For a few weeks until bred).
 2. Corn 88, tankage 12, salt.
 - B. Older Sows.
 1. Corn self-fed, tankage self-fed, salt.
(For a few weeks until bred).
 2. Corn 90, tankage 10, salt.
2. During Gestation or Pregnancy.
 - A. Gilts: Should gain about .6 to 1 pound daily.
 1. Corn 88 to 90, tankage 12 to 10, salt.
 2. Corn 50 to 75, alfalfa 50 to 25, salt.
To insure consumption, grind and mix.
 3. Corn 65, alfalfa 30, tankage 5, salt.
 4. Corn 30 to 50, skim or buttermilk 50 to 70, salt.
 5. (For self-feeder). Corn, ground, 48; alfalfa, ground, 48; tankage 4; salt. Increase or decrease the alfalfa to govern fatness of sows.

IV. (Cont.) BREEDING SOWS, CARRYING (PREGNANT).

2. (Cont.) During Gestation or Pregnancy.

B. Sows,—Yearling Sows or Older (Should Gain .5 to 1 pound daily).

1. Practically same as for gilts excepting slightly more corn may be fed, and somewhat less supplement. Old sows can “stand” more alfalfa hay if it is cheap enough.

V. SUCKLING SOWS.

1. Gilts and Older Sows.

A. Corn 70, middlings 15, tankage 15, salt.

B. Corn, all will clean up with a separate mixture (may be slopped or fed dry) made up of middlings 3 and tankage 1 fed according to appetite, salt.

C. Corn self-fed, middlings self-fed, tankage self-fed, salt.
It may be well to soak some of the corn for the sows with pigs following. Limit the feed first week to 10 days, getting up to a full-feed as quickly as conditions warrant.

FORAGE FEEDS AND FEEDING

There is considerable difference in the character of the various forages in so far as their supplemental value is concerned. Of all the forages which are practically grown in Iowa and the cornbelt in general the most successful ones, everything considered, given in order of merit are,—alfalfa; red clover or Dwarf Essex rape; bluegrass, preferably mixed with Alsike or white or other clovers; and sweet clover entire first year's or of the early second year's growth.

Alfalfa, rape, and red clover, along with tender bluegrass, are the standard pasture grass-

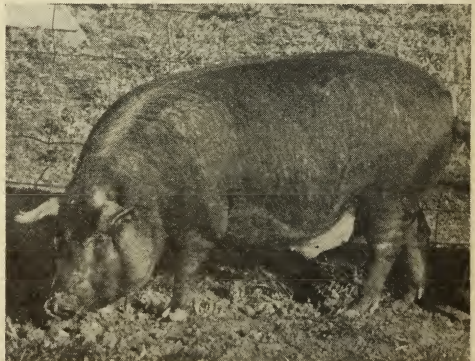


Fig. 3. SELF-FED ABUNDANT CORN AND SALT ON ALFALFA

Weighed Over 200 Pounds at Six Months.

es of Iowa. Alfalfa, rape, and red clover are the most uniform in general composition from the beginning to the end of the growing season, whereas bluegrass differs markedly in the early spring as compared to the middle of the summer.

Young, tender, shooting, green, succulent bluegrass, taken just as it begins to come thru the ground, oftentimes runs as high as 35 to 39 per cent protein in its dry matter, but this period of protein prosperity lasts but a brief time. In a few weeks to a month the protein content drops down to 25 per cent; a little later in the middle of the summer, when it becomes dry and hard, from 8 to 10 per cent protein content in its dry matter is about the average.



Fig. 4. HAND-FED LIMITED CORN AND SALT ON ALFALFA

Weighed under 100 pounds at six months. It does not pay to limit the corn ration too severely, it being fed to this pig at the rate of 1 pound per hundred live weight of pig.

Ordinary grazed alfalfa runs from 20 to 30 per cent protein in the dry matter of the edible portion thruout the season and good Dwarf Essex rape will run about the same.

It must be remembered that whereas real young, tender timothy runs high in protein that when this timothy becomes hard and fibrous it is quite low in protein, therefore, much more supplement should be fed in the latter stages of timothy growth than in the earlier ones. This is likewise true of bluegrass.

Fortunately it usually happens that these pastures such as bluegrass, timothy, rye, wheat, and others are especially rich in protein in the rapid growing season of the year, namely:—the spring or the fall following continuous showers, when the pigs are usually little—the spring or fall litters respectively coming on. Of course the very young pigs require a relatively high protein supplement in their ration; and it is luckily fortunate that the young, tender, shooting grass should be high in protein and growing rapidly simultaneously with the young, weanling pigs.

On high protein pastures much less high priced protein supplement is required than when the low protein pastures are depended upon. The rations most successful on the two different general classes of pasture follow.

ON HIGH PROTEIN PASTURES

Alfalfa; rape, Dwarf Essex; red, mammoth alsike, and white clover; young tender sweet clover; entire first year's growth and earliest stages of second year; quite early, tender, new coming timothy, rye, or wheat; and short, "shooting", tender, green, succulent bluegrass.

I. FATTENING AND GROWING HOGS FOR MARKET.

1. Suckling Pigs,—5 to 40 pounds—Creep.
 - A. Corn self-fed, middlings self-fed, tankage self-fed, salt.
 - B. Corn self-fed, tankage self-fed, salt.

It pays to give the suckling pigs a good start. However, on good alfalfa, or clover pasture they will eat but little tankage.
2. Weanling Pigs,—30 to 100 pounds.
 - A. Corn 0 to 95, tankage 10 to 5, salt.
 - B. Corn self-fed, tankage self-fed, middlings self-fed salt, When such pigs are self-fed on luscious, young alfalfa they eat about 94 to 96 corn and 6 to 4 tankage in going from weaning to 100 pounds weight.
3. Shots—100 to 175 pounds.
 - A. Corn self or hand-fed, salt.
 - B. Corn, self-fed, tankage self-fed, salt.

On good, high protein alfalfa such pigs will eat about 96 to 98 corn and 4 to 2 tankage.
 - C. Corn self-fed, middlings (only when relatively low in price) self-fed, tankage self-fed, salt.
4. Hogs—175 to 250 pounds.
 - A. Corn hand or self-fed, salt.
5. Fat Hogs,—250 to 300 pounds.
 - A. Corn hand or self-fed, salt.

II. FATTENING SOWS FOR MARKET.

1. Sows, Fattening off—All Ages.
 - A. Corn hand or self-fed, salt.

If in poor condition and not doing well feed same tankage or skim-milk or buttermilk until they get nicely started; the gilts will need somewhat more than older sows.

III. STAGS, FATTENING FOR MARKET.

- A. Corn hand or self-fed, salt.

IV. CARRYING SOWS, BREEDING (PREGNANT).

1. At Breeding Time and During Gestation.

- A. Corn with an addition of 5 to 10 per cent tankage until the sows are bred. Then put the sows on corn until about a month before farrowing time comes, when a limited amount of tankage or separated milk may be fed to them so as to encourage milk secretion. This method of feeding will also insure that there will be good strong, lusty, active new-born pigs.



Fig. 5. OVER 200 POUNDS AT 6½ MONTHS

Self-fed corn and tankage and salt in separate self-feeders on bluegrass—Free-Choice System.

V. CARRYING SOWS, SUMMERING—TO BE BRED IN THE FALL.

1. Fall Gilts and Yearling Sows.

- A. Corn limited ration, regulate according to gains and conditions desired. Change ration to corn and



Fig. 6. ONLY 72 POUNDS AT 6½ MONTHS

But they had plenty of tankage and salt, yet not enough corn,—only 1 pound per hundred weight daily on bluegrass.

tankage ten days before ing the sows liberally to encourage quick fertilization of many ova, in order to increase the number in the litter at farrowing time.

ON LOW PROTEIN PASTURES

Dry, hard, fibrous bluegrass; sorghum; feterita; millet; timothy when over 4 inches high; rye or wheat over 8 inches; or oats and barley over 5 inches, or beginning a couple of weeks before starting to joint; and sweet clover of second year's growth after ten feet high.

I. FEED PRACTICALLY SAME AS RECOMMENDED FOR DRY LOT

These pastures will, of course, save some grain feed, but they are not high enough or well balanced enough in the substances such as protein, minerals, and essential feed accessories that balance the corn to permit the lessening of the proportion of supplement used.

"HOGGING DOWN" CORN

Corn is "hogged-down" successfully in 99 of Iowa's 99 counties. The reason is not far to seek,—the pigs are superior corn harvesters. In general those swine best adapted to "hogging-down" purposes are forage grown spring shoters weighing from 100 to 150 pounds. Practically 95 per cent of Iowans who practice the economical "hogging-down" method prefer spring shoters, but, of course, other hogs can be used to advantage; in truth, any class of swine on the farm which are ready for fattening can be successfully turned into the cornfield.

I. WELL-GROWN FORAGE SHOTES OF 100 TO 150 POUNDS.

- A. Standing corn in which rape, or rye, or wheat, or soy beans, or cowpeas (in south) is growing, salt. Allow tankage if supplemental green feed is not abundant.
- B. Standing corn with run of adjoining field of alfalfa, or clover, or rape, or "luscious," new, tender growth bluegrass, or a happy combination of all these. Salt.
- C. Standing "clean" field corn with tankage fed from a self-feeder, salt.

If fattening sows, or well-grown, heavy-muscled, big boned yearling hogs of the previous fall's farrow, are used very little if any supplemental tankage will be needed,—nor rape, rye, wheat, alfalfa, or other pasture. However, if these pastures are available they may be used to some advantage.

SOME SUGGESTIONS WHICH MAY SIMPLIFY SUCCESSFUL FEEDING.

1. Ear corn is the best, most profitable all-around corn preparation; of course, shelled corn is excellent for the self-feeders, but ear corn will work splendidly if the self-feeder is paced on a "big enough" concrete, "non-wasting" platform.

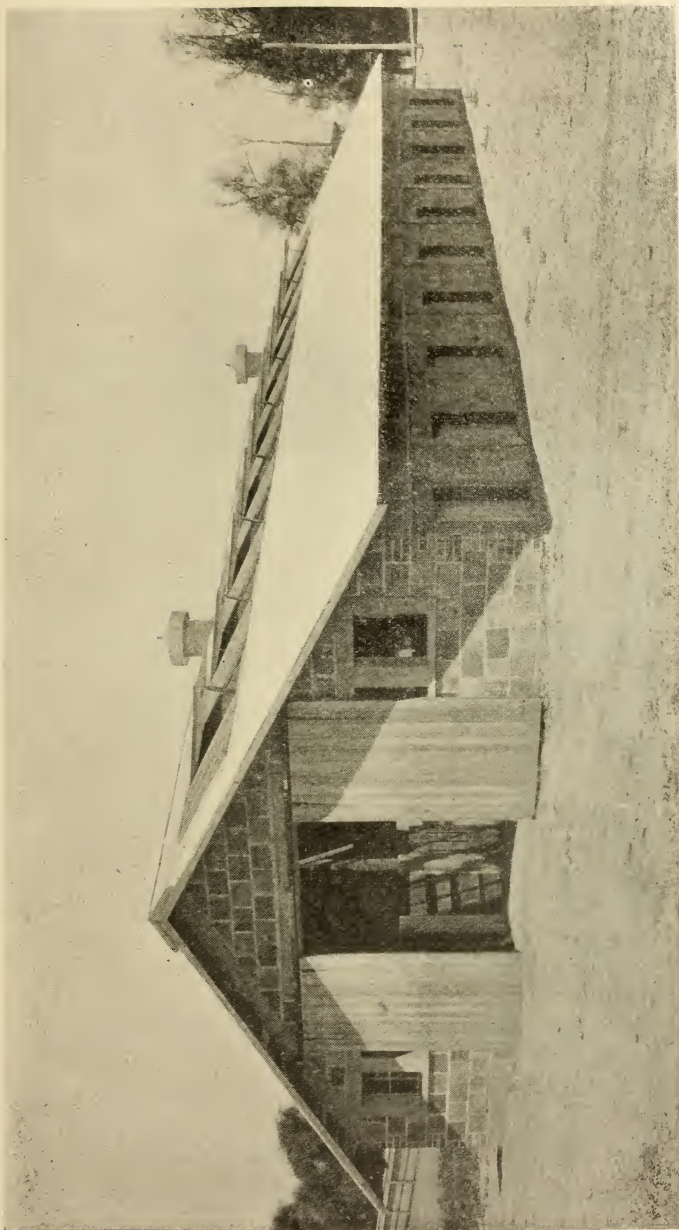


Fig. 7.—GOOD HOUSING, GOOD FEEDING AND GOOD BREEDING ALL COMBINE TO PRODUCE GOOD RESULTS.

2. Soaked shelled corn is excellent to start the little pigs; it is good for the suckling sows.

3. Common salt should always be fed to hogs, allowing it at free-will after they are accustomed to it. (Our experimental findings are indicating the truth of this suggestion.)

4. Charcoal made from corn cobs, or from wood, is excellent for swine, this being especially true when they are partaking largely of corn.

5. Barley, rye, wheat, speltz, Kafir corn, Milo-maize, sorghum seed, (all to be ground) and comparable feeds are quite similar to corn, and may be substituted for part or all of the corn in the rations given, provided they are abundant and cheap enough. Rye is sometimes likely to cause digestive troubles if fed in large quantities but that is dependent upon the local conditions. Barley is a most efficient substitute for corn and when properly supplemented produces a most excellent quality of pork, but its great drawback in the corn country is its relative high price. None of these feeds mentioned are the economic equal of corn when it comes to producing pork for profit in the corn belt.

6. Whole, skim, and buttermilk are our greatest physiologic corn supplements, but the former is too high priced to be used with profit in market production except for orphan pigs; and the skim and buttermilk are too scarce usually to be depended upon. The best supplements, therefore, are tankage, wheat middlings, and linseed oil meal. Pastures of alfalfa, the clovers, rape, bluegrass, and a few others, of course, are economically superior for the conditions in this corn country.

7. To substitute the tankage allowance (as given) with oil meal use about 2 to 2½ times as much, as for instance:—instead of using corn 90, tankage 10, use corn 90, linseed oil meal 20 to 25. However, oil meal as the lone supplement to corn is not advisable unless the pigs be on good pasture, and even here milk, middlings, or tankage are in order. If skim or buttermilk is substituted for the tankage use 20 times as much, or with middlings, 17 times as much with equivalent or equal corn amounts.

8. To secure greatest success in the feeding of hogs for profit look closely after these essentials:

a. Good, sound, healthy, prolific foundation stock of the right market type.

b. Good breeding, emphasis being placed on the matings that "nick". Have an ideal and breed toward it.

c. Good feeding, supplying the most profitable amounts of economical nutriment at the right time. This is a big problem which

demands eternal vigilance as the price of success. Self-watering is part of the successful feeding.

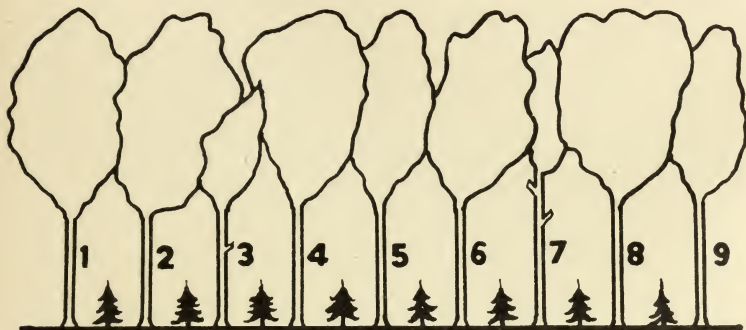
d. Good housing, comfortable, dry, well-lighted, and sanitary at all times.

e. Good, suitable, sanitary (worm and cholera free) range preferable or leguminous or similar pastures.

f. Good general management which will combine and recombine the many factors and forces at hand; the harmonious working of all the units so that the right thing will be done in the right way at the right time is the happy, profitable goal toward which to work.

TO BE MOST SUCCESSFUL IN THE SWINE BUSINESS ONE MUST LIKE IT, PUT HIS HEART INTO IT, YES—AND LIVE WITH IT.

RENEWING THE SHELTERBELT



In cover figure the new generation of trees have grown for five years under the old stand. Even shade-enduring trees, although getting a start, will not make a satisfactory growth in the dense shade of other trees, consequently the old stand should be opened up either gradually or at one operation.

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

Forestry Section

Ames, Iowa

RENEWING THE SHELTERBELT

BY G. B. MACDONALD

In removing the old decaying shelterbelt and replacing it with younger and better trees, it is not necessary to lose its protective value during the process. By following any one of the methods described in this circular the old stand of trees may be cut out and a new stand of the same or some other species secured while keeping the shelterbelt in a more or less effective condition.

On many farms in Iowa there is need of renewing the old shelterbelts. They were planted in the early days mainly for protection and and were made up of quick-growing, short-lived trees, such as the soft maple, cottonwood, willow and boxelder, having been planted heavily in the central and northern sections of the state. Some of these shelterbelts have yielded good returns in fuel and lumber in addition to affording protection to farm buildings. Others, through the trampling of stock and other causes, have yielded only small returns in wood products and only a little more in protection. Most of these short-lived groves which are still uncut are in various stages of decay and in many instances should be replaced with new stands of of longer lived species.

Five different methods for renewing shelterbelts in Iowa are presented in this circular: By renewing from one side; by renewing from two sides; by renewing by clear cutting; by renewing in alternate rows; by renewing by underplanting. Each method is illustrated with drawings which explain how the work is carried on for a shelterbelt of average size. Whatever system is used must be so adapted that it will meet the local conditions found in the shelterbelt that is to be renewed.

REGENERATION FROM ONE SIDE

In this method the object is to replace the present stand of trees gradually without losing much of the grove's protection value. If the grove is so old or in such poor condition that it will not hold together during the 15-year period required for regeneration, another system should be used which will take a shorter time.

METHOD OF REMOVING THE OLD TREES

Figures 1 to 5 show how the cuttings should proceed. In the case illustrated, it is assumed that the plantation is composed of 9 rows and that the trees will last at least 15 years longer. The rows run east and west and the grove is situated just to the north of the farm buildings.

First Step: During the winter or early spring remove all of the trees in the two south rows (8 and 9), leaving seven rows of trees for protection for the farm buildings. During the spring the blank rows should be planted up, preferably to one of the evergreen species mentioned later. The two new rows of trees will receive an abundance of light from the top and south side and also will be protected from wind damage by the old trees, which will insure a good growth. The new rows should be fully protected from stock and surface fires. Cultivation for several years will keep out weeds and grass and will increase the rate of growth.

Second Step: Five years from the time the two south rows are removed, cut out the next two (6 and 7) and replant in much the same manner as the first two. Great care should be exercised in felling the large trees so as not to damage the newly planted rows. At this time also replant the fall spots in rows 8 and 9.

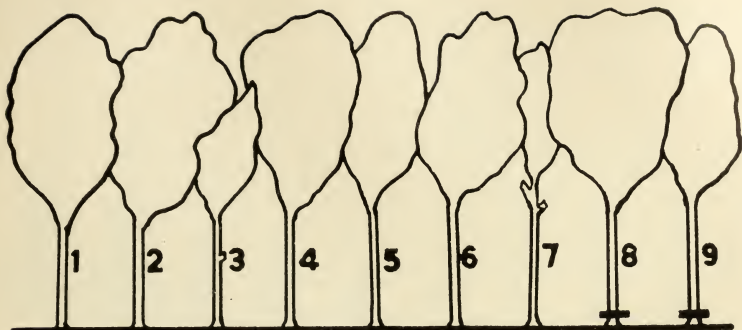


Fig. 1. Rows 8 and 9 are to be cut out first and planted up the same year with young trees of the new species.

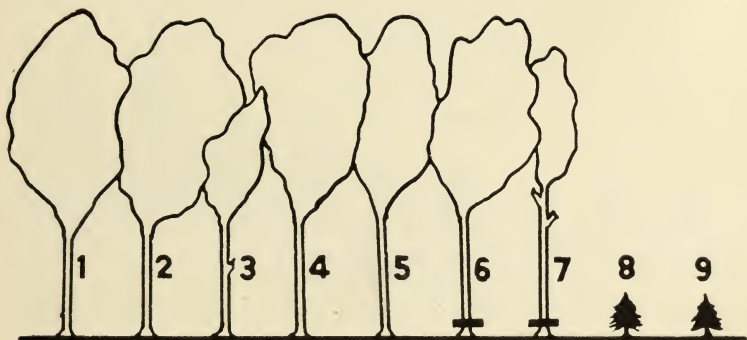


Fig. 2. At the end of 5 years, rows 6 and 7 are cut out and replanted. By this time the new trees in rows 8 and 9 should have made a good start.

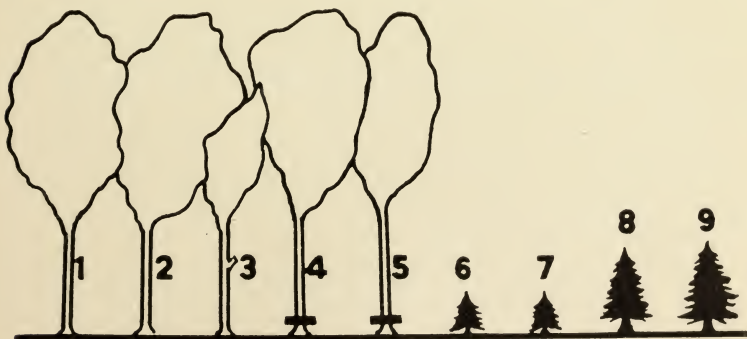


Fig. 3. After 10 years, rows 4 and 5 are cut out and planted. The new trees in rows 6 and 7 have made a good growth and those in rows 8 and 9 are large enough to give some protection.



Fig. 4. After 15 years, the remaining rows, 1, 2 and 3, are cut out and replanted.

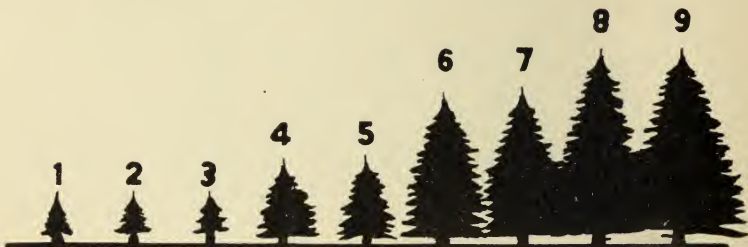


Fig. 5. After 20 years, the last rows, 1, 2 and 3, are 5 years old and 8 and 9, are 20 years old. The regeneration of the shelterbelt is completed.

Third Step: After another five-year period has elapsed, cut out rows 4 and 5 and replant them. This leaves but three rows of the old trees for giving protection. By this time, however, if broadleaf trees or fast-growing evergreens have been used for planting, the trees in rows 8 and 9 should be large enough to give good wind protection themselves, thus reinforcing the old rows remaining.

Fourth Step: After the third five-year period, cut out the remaining three rows of old trees and replant. If the plantings are successful, the regeneration is completed.

USE OF THE METHOD FOR DIFFERENT SHELTERBELTS

The method of regeneration from one side is adaptable to groves of any species, since the successive cuttings progress in a way to give an abundance of light to the new growth, no matter what the original grove is composed of.

Cottonwood: The cottonwood matures at an age of 35 to 40 years. It requires an abundance of light for growth and, as a result, stands of this species are relatively open. Many of these shelterbelts in the state are 35 to 40 years old and, under usual conditions, will last long enough for the application of this system of regeneration.

There will be difficulty in using the old trees for lumber, since it usually would not be profitable to bring in a portable sawmill every

few years for cutting up small amounts of lumber. However, where the plantation is large enough, the lumber can be used profitably for rough construction work on the farm. Round, split or sawed fence posts made from cottonwood trees will last for 25 years if given a good treatment with creosote.* In most sections of the state the wood has a ready value for fuel on the farm.

Soft Maple: Soft maple trees are quite tolerant of shade and, consequently, grow in a dense stand. The dense shading on the interior of the average soft maple grove makes it impossible to grow successfully under the old stand any except the most shade-enduring trees. However, under the regeneration method just described, the new trees are established outside of the grove proper, where shading interferes but little. Like the cottonwood, the soft maple is a short-lived tree and regeneration by this method should begin by or before the fortieth year if possible.

The relatively small number of maple trees removed periodically under this system should generally be used for fuel or fence posts. Soft maple fence posts when given a treatment of creosote, at a cost of 10 to 15 cents per post, will last for a period of 25 years.

Willow: The willow is also short-lived and the application of this method should be begun preferably before the trees are 35 years old. The willow sprouts persistently from the stump after the trees are cut down and usually considerable trouble is experienced in killing the sprouts. If the trees are cut in August, instead of in the winter, very few sprouts appear, and if these are promptly removed the stumps soon die. Under present conditions the willow has few uses except for fuel. However, after treatment with creosote, willow fence posts last for a long period of years and the wood from the old shelterbelt might profitably be used for this purpose.

Boxelder: Boxelder trees, although moderately rapid in growth, are always crooked, of small size and very short lived. They have little value except for wind protection. The regeneration by the method just described, should be begun as early as possible, even in young plantations. In old plantations (35 years), it is sometimes desirable to renew the grove by a quicker method, such as the clear-cutting system (see figs. 11, 12, 13 and 14). Use the trees removed for fuel or, if straight enough, for fence posts. Posts treated with creosote last as well as the cottonwood, soft maple and willow after treatment.

TREES ADAPTED FOR PLANTING

Practically any tree suited to the climatic, soil and moisture conditions can be safely regenerated under this first system. The selection of the variety or varieties to be used must be largely governed by the uses to which the shelterbelt is to be put and also by the likes and dislikes of the owner. If the new grove is to serve efficiently as a shelter from the winter winds, at least a portion of the new planting should consist of evergreens. If it is to serve also as a source of fuel, fence posts, and lumber, the trees best adapted for these purposes should make up a part of the new plantation. Care should be exercised in mixing species, so as not to have a row of fast-growing trees, such as some of the hardwoods, overtop and shade out previously planted rows of a slower growing, intolerant species such as the Austrian, Scotch, or western yellow pines.

The following evergreen trees, when only one species is used, are adapted for planting in regeneration from one side:

*See Bulletin 158, Iowa Agricultural Experiment Station. "The Preservative Treatment of Fence Posts."

White Pine: One of the most rapid-growing evergreen trees. Will grow on any except a poorly drained soil. A good windbreak tree when spaced 10 feet apart, in rows 12 feet apart. Produces saw lumber in 40 to 50 years. For this purpose it should be spaced 8 x 8 feet apart. Will endure a slight amount of shading when young.

Red Pine: Fairly rapid growth. Good for any but a wet soil. Will not endure shading.

Austrian Pine: Very hardy. Good for dry situations. Slower in growth than the white pine. Will not stand shading.

Western Yellow Pine: A hardy western tree suitable for dry situation. Similar to the red pine but of slower growth. Very intolerant of shade.

Norway Spruce: The best spruce for Iowa planting. Has a dense foliage and branches to the ground. Will stand shading. Should not be planted on very dry situations.

White Cedar: A shade-enduring evergreen of slow growth, making a good shelterbelt tree. It is not suitable for dry upland planting but will endure rather wet soils.

Red Cedar: A good windbreak tree. Suitable for very dry situations and soils of poor quality. Should not be planted near apple trees because of fungus trouble. Will stand shading.

European Larch: A tall, straight tree suitable for planting on good soils. Intolerant of shade. Not best for winter protection, since it sheds its leaves annually. Produces good pole timber.

Other evergreens which might be planted, but which are less desirable than the above, are the jack pine, Scotch pine, white spruce, and Douglas fir.

Broadleaf trees which might profitably be planted are the following:

Cottonwood: The fastest growing tree in Iowa. Good for quick results, but short-lived. Intolerant of shade. Will make fence posts* in six years and saw logs in 25 years on good soil.

Soft Maple: Fairly rapid grower. Will stand close spacing, and some shading. Short-lived. Can be utilized for fence posts (creosoted) and for fuel.

Hardy Catalpa: A small tree requiring full light. Good for fence posts. Should not be planted on exposed situations in northwestern Iowa without protection of other rows of trees.

Black Walnut: A fairly rapid grower, forming an open stand. Requires a moist soil. Is very intolerant of shade. Valuable for lumber but does not make a very effective windbreak tree, due to the thinness of its foliage.

Honey Locust: A fairly rapid grower. Intolerant of shade. Makes good posts.

Osage Orange: Not hardy in northern half of Iowa. A good fence post tree. Intolerant of shade.

Russian Mulberry: A small tree, giving protection close to the ground. Very tolerant and drought resistant. Not hardy in northern Iowa. Wood very durable.

Green Ash: A medium-sized tree of moderate growth and quite hardy. Makes fair fence posts.

A large number of hardwood trees might be added to the above list, but in planting, care should be taken to select only those trees adapted to the local climatic and soil conditions.

*Cottonwood posts are not durable unless treated with a preservative.

COMBINATIONS OF SPECIES FOR PLANTING

Various combinations of trees may be planted under this system of regeneration from one side, but, as a rule, two or three species are sufficient. If the rows are to be of different varieties, the principal care should be to see that the rapidly-growing hardwoods do not overtop and suppress the slow-growing trees. The intolerant evergreens, being of slow initial growth, are in more danger of being overtopped than the hardwood trees.

The following are some of the combinations which might be used:

Combination No. 1. Rows 8 and 9, white pine; rows 6 and 7, Norway spruce; rows 4 and 5, European larch; rows 1, 2 and 3, white pine.

Combination No. 2. Rows 8 and 9, white cedar or Norway spruce; rows 4, 5, 6 and 7, white pine, red pine or Austrian pine; rows 1, 2 and 3, white cedar or Norway spruce.

Combination No. 3. Rows 8 and 9, European larch (bare in winter); rows 6 and 7, white cedar or red cedar;* rows 4 and 5, Norway spruce or white spruce; rows 1, 2 and 3, cottonwood.

Combination No. 4. Rows 8 and 9, white cedar, Norway spruce or white pine; rows 6 and 7, red pine, Austrian pine, western yellow pine, or Douglas fir; rows 4 and 5, Norway spruce or white cedar; rows 1, 2 and 3, hardy catalpa.

Combination No. 5. Rows 8 and 9, white pine; rows 6 and 7, Norway spruce or white cedar; rows 4 and 5, cottonwood; rows 1, 2 and 3, green ash, or Russian mulberry.**

VARIATIONS IN THE METHOD

In this first regeneration process, the five-year period between successive cuttings need not necessarily be adhered to. The period might be reduced to three years or less. In the case of a shelterbelt composed of three or four rows of old trees, only one row should be cut at a time, unless the trees are in very poor condition.

REGENERATION FROM TWO SIDES

In this method it is also the purpose to secure a new growth of trees without sacrificing entirely the efficiency of the windbreak. By reference to the diagrams in the figs. 6 to 10, it will be noted that instead of a gradual removal of the trees from one side, as was the case in the first method, single rows are taken from each side at intervals of five years. The time between the first and the last planting is the same as in the first method of cutting—15 years.

Figures 6 to 10 show how the cuttings should proceed. In the case illustrated, it is assumed that the shelterbelt is composed of nine rows of trees, most of which will last through the regenerative period of 15 years.

*Red cedar should not be planted if apple trees are in the vicinity because of fungus trouble.

**For Southern Iowa only.

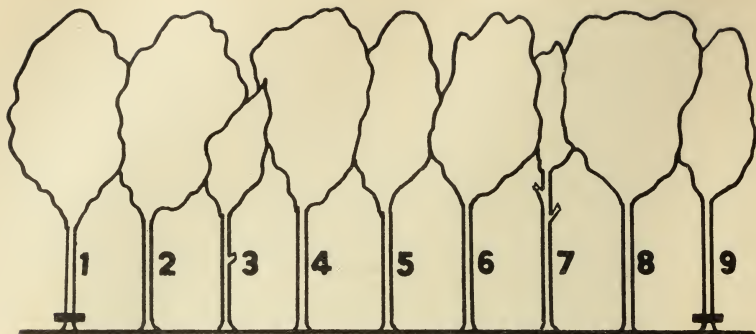


Fig. 6. At the beginning the two outside rows, 1 and 9, are cut out and replanted the same year with young trees of the new species.

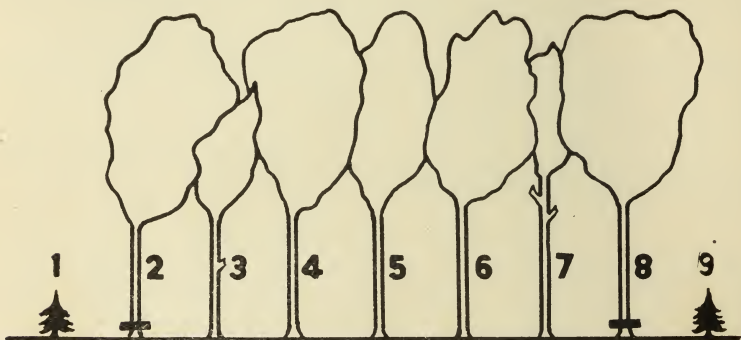


Fig. 7. After 5 years, rows 2 and 8 are cut out and planted with new trees; the trees in rows 1 and 9 are 5 years old.

At the beginning, rows 1 and 9 of the old plantation are cut out and replanted to the new species. Five years later rows 2 and 8 are taken out, and after another period of five years, rows 3 and 7 are removed. At the last cutting, rows 4, 5 and 6 are replaced with young trees. It will be seen that fair protection from the wind is afforded by the old trees, even up to the last cutting, and by this time some of the newly-planted trees should be sufficiently high to give some protection.

USE OF THE METHOD FOR DIFFERENT SHELTERBELTS

This second method should be almost as successful in regenerating short-lived shelterbelts of cottonwood, soft maple, willow and boxelder, as the method of planting up from one side. There is one slight disadvantage; the new trees planted directly north of the old rows will receive less light than those planted to the south, consequently, some care should be exercised in the selection of species for planting. The shading is most severe in the cases of soft maple and boxelder shelterbelts, since the foliage of these trees is much more dense than that of the cottonwood or willow.

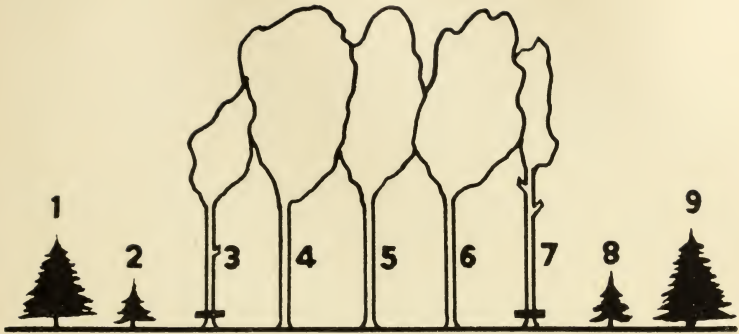


Fig. 8. After 10 years, rows 3 and 7 are cut from the shelterbelt and replanted.

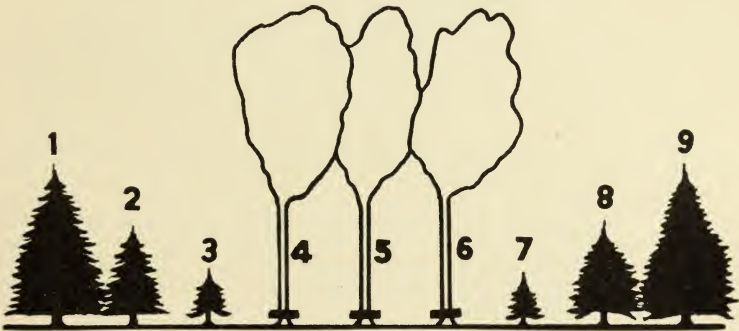


Fig. 9. After 15 years, the remainder of the old planting, rows 4, 5 and 6, are cut out and replanted.

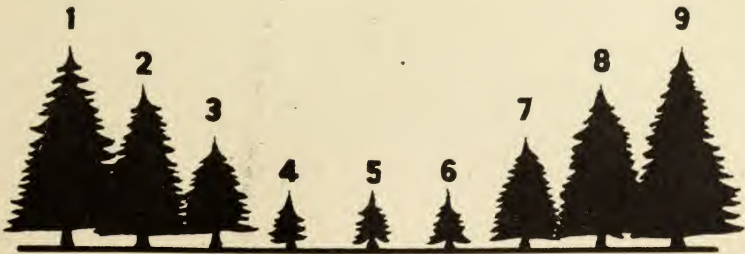


Fig. 10. After 20 years the youngest trees, in the interior of the grove, rows 4, 5 and 6, are 5 years old and the oldest, rows 1 and 9, are 20 years old.

In the case of groves which should be replaced at once with new trees, employ the clear-cutting system rather than the above plan. However, it is seldom that a plantation, even of the short-lived species, is so far gone that it will not remain in fair condition for 10 to 15 years. This method has certain disadvantages over the first, since it is more difficult to cut out the old trees in single rows without damaging the newly-planted ones. This is especially true when the original spacing of the trees is close.

If the old timber is to be utilized for lumber, difficulty may be experienced in getting a small number of trees sawed at a reasonable price. However, if the woodlot is to be used for fuel or fence posts, the timber can be cut economically for these purposes.

SPECIES USED IN REPLANTING

The list of species suitable for planting under this method is almost identical with the one given under the preceding first system. It should be borne in mind, however, that the newly planted trees to the north of the old rows will receive less light than those planted on the south side. As a result, if this shading appears to be excessive, trees which are somewhat tolerant of shade should be selected for this portion of the new shelterbelt.

It is very often desirable to have a shelterbelt of evergreen and hardwood trees. As a rule, the evergreens give good protection close to the ground and also serve as an effective windbreak throughout the year, while the larger hardwoods break the wind, at a distance from the ground but are not as effective during the winter months.

Combination No. 1. Rows 1 and 9, white pine; rows 2, 3, 7 and 8, Norway spruce; rows 4, 5 and 6, cottonwood.

The white pine rows being on the outside, receive an abundance of light at all times for best development. The Norway spruce on the interior will receive sufficient light for good growth, since they are very tolerant of shade. The cottonwoods in rows 4, 5 and 6, although planted last, would reach a height greater than any of the evergreen trees in a few years.

Combination No. 2. Row 1, Norway spruce; row 9, white pine; rows 2 and 8, white cedar; rows 3, 4, 5, 6 and 7, hardy catalpa.

The white pine trees in row 9 are not only effective as a windbreak, but also make a very beautiful row to face the farm buildings. The Norway spruce used in row 1, branches very close to the ground, has dense foliage, and, consequently, would be very effective in breaking the force of the wind. The white cedar, if closely spaced, makes a dense mass of foliage and is valuable for windbreak purposes. Although the hardy catalpa in the inside rows does not make a large tree, it is very desirable for fence posts. It is assumed in this combination, that the hardy catalpa rows can be harvested for fence posts in 12 years. Since the catalpa trees in rows 4, 5 and 6 are planted five years later than those in rows 3 and 7, the branches of the older trees should be trimmed back if there is danger of the later planting being shaded too severely. The catalpa is very intolerant of shade and will not thrive if overtopped by adjoining trees.

Combination No. 3. Row 1, white pine; row 9, white cedar; rows 2, 3, 7 and 8, Norway spruce; rows 4, 5, and 6, white pine.

The white pine in the interior rows, although planted last, is sufficiently rapid in growth to prevent its being overtopped by the

adjoining rows of Norway spruce, although the latter are planted five years earlier.

Combination No. 4. Rows 1 and 9, white cedar; rows 2 and 8, Norway spruce; rows 3, 4, 5, 6 and 7, cottonwood.

The evergreens on each flank of the shelterbelt will give efficient protection against the wind close to the ground and, at the same time, will give a pleasing effect to the windbreak both in summer and winter time. The interior of the plantation will, in a few years, not only break the force of the wind at some distance from the ground, but also be a profitable source of saw timber or fuel.

Combination No. 5. Row 1, white pine; row 2, white cedar; row 3, white spruce; rows 4, 5 and 6, red cedar;* row 7, Jack pine; row 8, western yellow pine; row 9, European larch.

The above combination makes an effective shelterbelt of coniferous species. The larch trees in row 9 shed their leaves during the winter.

VARIATIONS IN THE METHOD

It will seldom happen that the plan illustrated under this method will exactly fit conditions found in other shelterbelts. The method should be considered as suggestive and altered to suit local conditions. In the case of a shelterbelt which has only three or four rows, it would no doubt be preferable to use the system of regeneration from one side, taking out one row at each period instead of two rows. In the case of a plantation much wider than the one illustrated, it might be preferable to take two rows of trees at a time from each side instead of one row. There is no necessity of adhering to a uniform period of five years between cuttings. This may be either lengthened or shortened to suit convenience or necessity. On the other hand, a plan should be prepared and the work should follow a definite schedule or the regeneration will unquestionably prove a failure.

REGENERATION BY CLEAR-CUTTING

The method of clear-cutting is only employed when the windbreak can be dispensed with while the new stand of trees is growing, or where the old timber is in such poor condition that it must be renewed at once. Under such conditions, it is advisable either to cut everything on the plantation or to leave only a row or two to give some protection for a few years.

Under this system it is advisable, where conditions will permit, to leave two rows of the old trees after the first cutting, these rows to be removed during the second and third steps, respectively, in the regeneration process. (See figs. 11, 12, 13 and 14.)

The system has several advantages. In cases where the old plantation is to be cut into lumber (cottonwood for example), the trees can be sawed at a minimum cost, since most of the plantation is removed at one time. In addition, by removing practically all of the stand at once and replanting, there is no damage to the new stand of trees. On the other hand, where the timber is to be used for fence posts and fuel, it very frequently happens that there is not

*Red cedar should not be planted in the vicinity of apple trees.

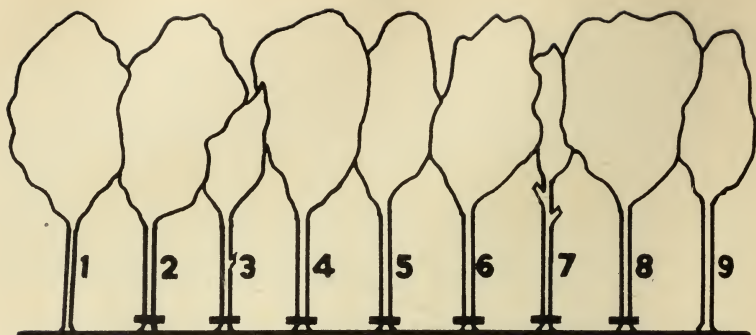


Fig. 11. At the beginning, rows 2, 3, 4, 5, 6, 7 and 8 are cut out. The rows are replanted the same year to either evergreen or broadleaf trees. The original trees in rows 1 and 9 are left temporarily for shelter and also to give some protection to the new crop of trees.



Fig. 12. After 5 years the trees in row 9 are cut out and replanted. The old trees in row 1 preserve partly the effectiveness of the shelterbelt at some distance from the ground. If the interior trees are of the broadleaf class the effectiveness of the shelterbelt would eventually be increased by planting evergreens in row 9.

a market for this material except on the home place. Consequently, it would entail a great waste of material, through decay, to store up for a number of years a supply of fuel or posts made up of undurable woods.

At the beginning of the regeneration period, all except the two outside rows of trees are removed and replanted. After five years' time, the south row (no. 9) is removed and replanted. At the close of another five-year period the last row of old trees (no. 1) is replaced. The outside rows being more thickly branched will give fair protection against the wind. In case the trees are in such poor condition that they will not last for even a few years, it would then be desirable to take out all of the old trees at the first cutting. Under such circumstances, a portion of the new growth should be made up of the most rapidly growing trees available, in order that the grove may become effective against the wind as soon as possible.

The clear-cutting method, from a cultural standpoint can be more generally applied than any of the other systems suggested. In a pure plantation, established at one time, there is less danger of excessive crowding and overtopping, since the trees are equal in rate of growth and shade-enduring qualities. If the new shelterbelt is to

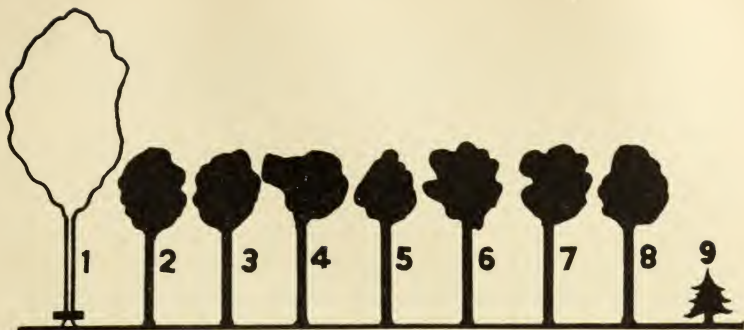


Fig. 13. After 10 years the newly planted trees are large enough to permit the removal of the remaining old trees, row 1, without injury. This row should be planted the same year.

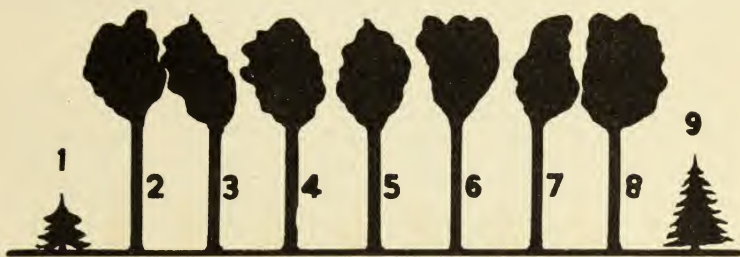


Fig. 14. After 15 years the regenerated shelterbelt should give good protection.

be composed of different species, care must be exercised in the selection of combinations, to prevent overtopping and killing the slower growing or intolerant trees.

This system should be applied to cottonwood, soft maple, willow and boxelder shelterbelts which are too old or degenerate to be satisfactorily regenerated by one of the slower methods, or where the protective feature of the grove is not of great importance.

SPECIES USED IN PLANTING

When one species is to be used throughout the entire shelterbelt, any tree which is suited to the climatic, soil and moisture conditions of the locality may be used. The following is a partial list of trees which might be used: Cottonwood, hardy catalpa, soft maple, hard maple, black walnut, red oak, white pine, red pine, Austrian pine, western yellow pine, Norway spruce, European larch, red cedar, white cedar.

COMBINATIONS FOR REPLANTING

Combination No. 1.

The Norway spruce, white cedar or red cedar might be alternated with the cottonwood or other thin-crowned, fast-growing species. These evergreens are tolerant of shade and would make a fair growth under the light shade of trees such as the cottonwood.

Combination No. 2.

Norway spruce and white cedar, where conditions are suitable, might be planted in alternate rows. After 30 to 35 years, the Norway spruce begins to overtop the white cedar, but the combination makes one of the most efficient shelterbelts that can be grown in Iowa.

Combination No. 3.

Any broadleaf species suitable for the region might be used on the interior rows of the plantation, these rows to be flanked by the planting of any evergreen suiting the locality, in the outside rows 1 and 9.

Combination No. 4.

Alternating rows of European larch and Norway spruce. The European larch when planted alone makes a rather open stand. The tolerant Norway spruce, being of slower growth, will form an under story which will keep out grass and weeds, benefiting both species.

VARIATIONS IN THE METHOD

One block, making up from one-fourth to one-half of the plantation, might be renewed in one year, and the balance of the plantation in the years immediately following. This would distribute the planting over several years, which might be advantageous under certain conditions.

REGENERATION BY ALTERNATE ROWS

The method of regeneration by planting alternate rows may well be used in shelterbelts where the original spacing is wide. Many cottonwood plantations might be renewed by this system. Disadvantages are to be found, however, in the fact that only the shade enduring species can be used for planting between the old rows left standing after the first cut and, later, when the remaining old trees are removed it is practically impossible to fell the timber without damaging the young trees which have been planted.

Under this system the entire stand of old trees is removed in two cuttings. The second cutting should generally follow the first after about 10 years, but this period can either be shortened or lengthened to suit conditions (see figs. 15, 16 and 17.) Fairly good windbreak protection will be afforded until time for the last cutting of the old timber. At this time, unless the period between cuts has been of considerable length, the efficiency of the windbreak is likely to be impaired for a number of years, inasmuch as the tolerant trees which are used in replanting are generally of slow growth and will not be tall enough to give much protection against the wind in a period less than fifteen or twenty years.

This system could be used in certain cases in cottonwood or willow plantations which are rather open. As a rule, it could not well be used in dense plantations of either soft maple, boxelder or other species forming a very heavy shade. For the reasons already given, this system is not as desirable as some of the others already described.

SPECIES USED IN REPLANTING

A list of trees suitable for replanting by this method will be restricted, except under exceptional cases, to those which are tolerant of shade. This list will include:

Norway spruce
White cedar
Red cedar
White spruce

Hard maple
Soft maple
Basswood
Boxelder

In no case should trees intolerant of shade be used except where it is evident that they will not become overtopped by the adjoining trees. It might sometimes be possible to use a fast-growing, intoler-

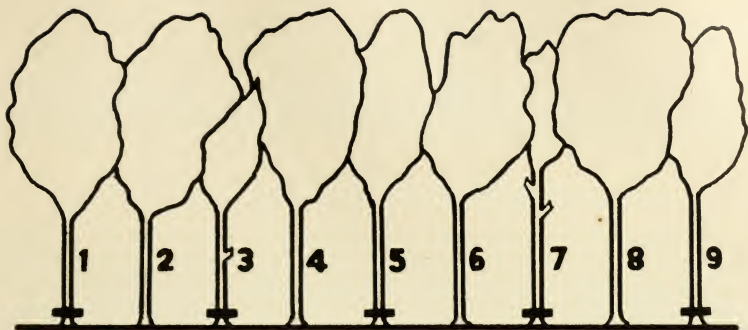


Fig. 15. Alternate rows, 1, 3, 5, 7 and 9, are removed at the start. Also remove broken, suppressed and otherwise defective trees in rows 2, 4, 6 and 8. Replant the open rows and blank spaces the same year. Only shade-enduring trees should be used except for the outside rows.

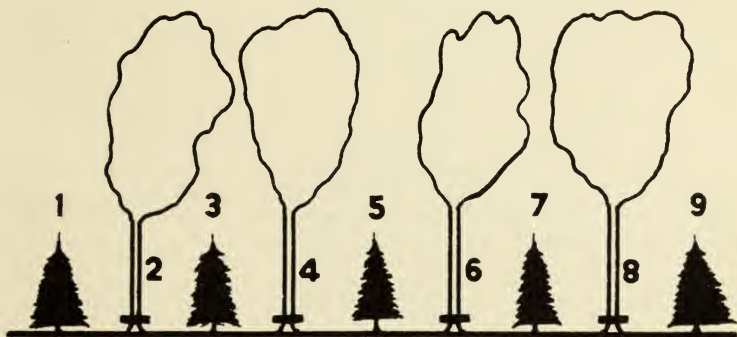


Fig. 16. At this period the regeneration is only partially completed. The remaining trees in rows 2, 4, 6 and 8 should be removed and replanted.



Fig. 17. The trees of the first replanting are 20 years old, rows 1, 3, 5, 7 and 9, and those of the second replanting are 10 years old, rows 2, 4, 6 and 8.

ant tree, such as the cottonwood, for planting in the rows taken out during the second cutting. For example, if Norway spruce were planted in rows 1, 3, 5, 7, and 9 (see fig. 17), and cottonwood in rows 2, 4, 6 and 8, ten years after the Norway spruce had been planted, there is little question but what the cottonwood, in a few years, would overtop the adjoining Norway spruce, since the former is much more rapid in growth.

REGENERATION BY UNDERPLANTING

The object of the method of underplanting is to provide for a new growth of trees under the shade of the existing stand, without the removal of any except diseased or suppressed trees for a period of years. This method can only be used profitably in plantations where the original spacing was rather wide, or at least only in plantations where there is some direct light reaching the ground.

It is evident that in planting new trees between the old rows without the removal of any of the old stand, only the most shade enduring species can be used. This point should be thoroughly kept in mind, since a considerable loss and much delay might result in underplanting with the wrong species. Aside from this the greatest disadvantage is in the removal of the old stand of trees after the young growth has developed for 5 to 10 years in the shade. It is impossible to cut and remove the large trees without breaking and damaging the young growth to a greater or less extent. (See cover page figure.)

The system would be most applicable to relatively young stands of trees in which a reinforcement of evergreens is desired, as, for example, a young open stand of cottonwood trees might very well be underplanted with such a tolerant tree as the Norway spruce.

The proper time for cutting out the old trees must depend entirely upon conditions, and it is impossible to specify any definite time. The removal of the large trees might either be gradual or be done at one operation. In any event, the overtopping trees should be taken out when the new growth is being crowded or is suffering from lack of light. In certain stands of a very open nature, the trees making up the underplanting might be permitted to grow to a large size without cutting out any of the overtopping trees. However, this would be an exceptional case.

The application of this method to groves of different species depends more on the openness of the stand than on the species itself, since the system could be applied to any grove if the old trees were widely spaced. The system, as a rule, will more generally apply to cottonwood and willow plantations than to soft maple and boxelder groves, since the two former are never found in as dense a stand as the last two.

SPECIES FOR UNDERPLANTING

As previously stated, only tolerant trees should be used in this method of regeneration. The following trees are suitable within their range and under proper soil conditions, for use under this method:

Norway spruce
White spruce
White cedar
Red cedar

Basswood
Hard maple
Soft maple
Boxelder

The above list of trees might be used in various combinations successfully.

SEED CORN FOR THE 1916 CROP

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND THE MECHANIC ARTS

AGRONOMY SECTION

Farm Crops



Ames, Iowa

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SEED CORN FOR THE 1916 CROP

By H. D. Hughes and W. W. Stanfield

FACTS REGARDING SEED CORN FOR THE 1916 CROP

1. The 1916 corn crop depends absolutely on the **INDIVIDUAL EAR TEST**.
2. There is enough seed corn in the state of Iowa to plant this year's crop, providing the individual ear test is used effectively.
3. There is comparatively little corn in Iowa which is fit for seed in its present condition. It will be absolutely essential that much of the corn which gives a low germination test, be gone over by the individual ear method, separating the good from the bad, if there is to be enough good seed to plant this year's crop.
4. Nearly one-half of the farmers in many localities will need to purchase some seed corn this year.
5. If seed must be purchased, **GET THE SEED NOW**. Don't wait even a week. Get it and test it at once.
6. It is neither safe nor is it necessary to buy seed from distant points, and of which nothing is known regarding its value or its adaptation to Iowa conditions.
7. Get seed from your own immediate community if possible. Buy from the men you know. Locally produced seed will give a greater yield of better quality corn than seed brought from a distance.
8. Enough seed for the 1916 crop can be made available in nearly every community. For a few limited sections some seed will need to be secured from nearby counties.
9. Don't buy any seed unless you have reason to believe that it will grow. Don't take the other man's word for it. He may be honest, but remember that honest men have, in the past, sold seed corn which looked good and which they probably believed was good for seed, yet which proved to be dead. Our reports show that this is happening right along this year.
10. Buy seed on your own test. Test a sample before buying and also test after buying.
11. Buy from the men who will allow you to sample the seed yourself before buying.
12. If you buy seed from a seed house, buy from a well-known firm which has years of honest business to its credit and with a reputation to maintain. Such seedsmen will be glad to sell you seed subject to your own germination test. Order your seed now. Test it immediately upon arrival. Return it promptly if it is not satisfactory.
13. Do not, under any conditions, buy seed from an agent. This is a most dangerous and unsatisfactory practice. Deal direct with a reputable firm.
14. **FIND YOUR SEED AT ONCE. USE THE PHONE! DRIVE! USE THE RAILROADS IF NECESSARY. SEE THE CORN! SEE AS MANY DIFFERENT LOTS AS POSSIBLE. TAKE SAMPLES! TEST IT! BUY SEED YOU KNOW WILL GROW.**

Iowa farmers face an unusual problem in securing good seed corn for the 1916 crop, but it can be solved.

Very careful investigation in every section of the state shows that there is enough seed in the state to plant this year's crop, providing thorough effort is made to locate it and the individual ear test is used in separating the good from the bad. The individual ear test is absolutely essential on every farm in Iowa. There can be no certainty of anything like an adequate crop this year without it.

In many localities nearly half the farmers will have to buy

seed. It is important for them to bear in mind that locally produced seed will yield more and better corn than seed brought from a distance. Seed that is imported is always uncertain as to its results and that is doubly true this year.

It is unnecessary to dwell on the conditions responsible for the unusual seed corn situation which confronts Iowa farmers. Suffice it to say that excessive rainfall at the usual planting time delayed planting until later than usual, and that the comparatively low temperatures throughout the summer delayed the ripening of the crop to such an extent that a very large part of the crop was immature when killing frosts occurred very much earlier than usual, as early as late August.

To make matters worse, the unusual season seriously injured the vitality of much of the 1914 corn which was in cribs and made it unfit for seed.

INVESTIGATION OF SEED CORN CONDITIONS

In view of these unusual circumstances plans were laid early in the winter to give special assistance to those sections most seriously affected. As a result nearly one-third of the counties of the state made provision for seed corn surveys. These have been completed in a number of counties, others are now under way, while still others will be surveyed during the next few weeks. In each county in which the farmers and business men have been sufficiently interested to perfect a county organization, guaranteeing the necessary local expenses, providing for meetings, etc., the college has coöperated in providing a man from the Agricultural Extension department to do the work of examining and testing the various cribs found.

In making these surveys one day is spent in each township examining the seed corn available and taking samples for testing. This makes it possible to get in touch with practically every lot of seed corn in the county.

The following counties with agents began work last August and have been continuing the work more or less effectively ever since: Clinton, Scott, Muscatine, Linn, Henry, Des Moines, Montgomery, Wright, Black Hawk, Greene, Clay. In January Sioux, and Emmett counties also began work with agents. Eighteen other counties have received or are receiving special help from the college: Cerro Gordo, Floyd, Chickasaw, Mitchell, Worth, Winnebago, Allamakee, Jackson, O'Brien, Jefferson, Pocahontas, Franklin, Humboldt, Bremer, Delaware, Buena Vista, Palo Alto, and Butler.

This makes 31 counties to date and several other counties have the matter under consideration.

The tests reported from the various counties indicate that some seed will need to be imported into several sections, notably

into the counties of Chickasaw, Floyd, Worth, Mitchell, and Winnebago, and possibly some others. Considerable difference in the condition and amount of seed corn available have been noted in adjoining counties and even in different parts of the same county. The conditions found to exist in one locality may not be found in nearby localities.

It is an interesting fact that the most favorable conditions are found in those communities which have had agricultural short courses or which have had vigorous farmers' institutes.

While the primary purpose of this publication is to give information for those parts of the state in which county surveys have not been made, it seems desirable to present this brief statement of the county survey work. The meetings held in each township in the counties surveyed gave very complete information to those counties directly concerned.

GENERAL SURVEY

In order to secure some additional information regarding the supply of good seed in the different parts of Iowa, and particularly in those counties not surveyed but reported as vitally concerned, the Farm Crops section of the Iowa Agricultural Experiment Station made a general survey of several representative districts. The agent of the station visited the farms in the various communities in regular order without any selection whatever, believing that this was necessary in order to secure accurate information as to the real conditions. The agent took samples personally, using special care to insure their being truly representative.

The localities visited, and from which data have been secured, covering the amount and vitality of the seed corn available, also the acreages to be planted this season, are as follows:

Section of State	County	Town	Lots of Corn Inspected
Northern Iowa (central)....	Kossuth	Algona	44
Northern Iowa (east).....	Winneshiek	Decorah	66
Northern Iowa (east).....	Allamakee	Waukon	
North Central (central)....	Wright	Goldfield	110
North Central (east).....	Bremer	Waverly	117
North Central (east).....	Fayette	Oelwein	37
Central Iowa (east).....	Muscatine	Muscatine	63
Central Iowa (e. central)....	Cedar	Clarence	31
Southern Iowa (east).....	Monroe	Albia	78

MORE SEED AVAILABLE, LOCALLY, THAN IS COMMONLY SUPPOSED

From table I it will be noted that enough seed to plant the 1916 crop and to spare was found in every locality visited by the representative of the experiment station, provided the seed which shows considerable vitality, yet is not fit for seed in its present

condition, is given the individual ear test, separating the good from the bad. Some idea can be had regarding the average vitality of different kinds of seeds from table II.

In a number of communities investigators were told by nearly every farmer visited, that there was practically no seed in the community except the small amount which he himself had. Later it was shown that each one of these communities had enough seed and to spare, provided the available corn were carefully tested by the individual ear test. Many of these communities organized to select the best corn for seed and to make tests. In other localities which were not organized to do this each farmer has his own individual problem of testing and it is a most important problem. He must determine definitely whether he has enough tested, dependable seed for his acreage. If he has not then he must find his seed at once.

The number of farms without any seed were comparatively scarce, many having some seed of both 1914 and 1915. The number of farms with seed and the kind is shown in table III.

TABLE I. SHOWING THE AVERAGE CORN ACREAGE, THE SEED REQUIRED AND THE AVERAGE AMOUNT AVAILABLE, PER FARM, IN THE AREAS SURVEYED

County	Average Corn Acreage Per Farm	Bu. of Seed Required Per Farm	Average No. of Bushels of Seed Corn Available per Farm					
			No. 1 Seed from				No. 2** Seed from	
			1915 Seed	1914 Seed	1914 Crib	1915 Seed	1914 Seed	1914 Crib
Kossuth	60	10	6.1	3.0	98	2.4	2.5	15.5
Wright	60	10	5.9	11.3	127.1	1.0	6.5	63.6
Bremer	45	7.5	8.7	1.5	31.0	1.4	0.3	0.7
Fayette	45	7.5	5.6	1.1	20.7	1.1	0	4.1
Muscataine ..	97.3	13.3	13.5	0.6	1.2	0.7	0.1	0.1
Cedar	45	7.5	7.8	5.9	63.0	0.7	0.5	95.0
Monroe	34.2	5.7	2.5	0.5	14.5*	0.6	0.1	8.0*

TABLE II. SHOWING THE AVERAGE PER CENT OF EARS TESTING STRONG, WEAK, AND DEAD, ALSO THE GERMINATION, OF 423 LOTS OF SEED CORN SECURED IN 8 COUNTIES IN IOWA

Kind of Corn	Place of Storage	No. of Lots	Per Cent of Germination					
			Ears			Kernels		
			Strong	Weak	Dead	Strong	Weak	Dead
1915 seed....	House	196	75	16	9	88	6.5	5.5
1915 seed....	Outbuildings	59	60	18	22	75	8	17
1914 seed....	House	86	64	17	19	70	12	18
1914 crib....	Crib	79	34	16	50	55	10	45
1913 seed....	House	3				84	11	5
	Total	423						

* Most all 1915 crib.

** Seed ears testing 5-0-1 or better but not No. 1 seed.

TABLE III. SHOWING THE SEED STOCK ON FARMS VISITED IN THE GENERAL SURVEY

County	No. of Farms Rep- resented	No. with both '14 & '15 Seed	No. with only '15 Seed	No. with only '14 Seed	No. with No Seed
Kossuth	40	11	15	11	3
Winneshiek	45	17	23	3	2
Wright	62	26	14	17	5
Bremer	53	26	16	5	6
Fayette	41	11	25	1	4
Muscatine	45	5	26	4	10
Cedar	12	9	0	3	0
Monroe	68	6	50	6	6
Total	366				

UNUSUAL AMOUNT OF SEED MUST BE BOUGHT

A greater number of Iowa farmers will purchase seed corn this year than in any previous year of which this station has knowledge. Data secured from representative areas in the state indicate that some seed corn will need to be purchased on approximately 35 per cent of the farms. In only one community was enough seed found on every farm visited to plant the 1916 crop. Of the 35 farms visited in Muscatine county, 42 per cent must buy seed; 37 per cent must buy even though they plant every ear of seed they have, be it good or bad. If every ear of seed, regardless of quality, is planted on the 44 farms visited in Kossuth county, 32.5 per cent must buy. This is true of 25 per cent of the farms visited in Bremer county and of 38 per cent of the farms visited in Winneshiek and Allamakee counties; 46 per cent in Fayette, 13 per cent in Wright, and 38 per cent in Monroe. A considerably larger number will need to buy seed than is indicated since many of the seed ears must be discarded because of low vitality. As great a per cent will need to buy seed in parts of southern Iowa as in many of the northern Iowa counties.

LOCAL SEED BEST

Too many will buy seed when better seed can be found right on the farm than can be secured anywhere else. It is always uncertain to buy seed and that is doubly so this year. One is likely to pay much more than it would cost to separate out the good ears by means of the germination test.

Untested seed has sold at farm auctions for as much as \$7.40, \$9.00, and \$11.30 per bushel. A Story county sale bill listed 75 bushels of seed, the germination as reported by the college to be announced on the sale date. The college tested the corn under the most favorable conditions, found it to be 97% dead, and so reported the test to the owner. On the day of the sale the corn was sold as carefully selected seed corn without test, the statement being made that the college had failed to report. Seed grown as far south as Oklahoma is being sold through agents to

Iowa farmers for planting the 1916 crop. There can be but one result. Such corn will never mature. Seed which is moved any distance will not give as good results as locally grown seed.

During a period of seven years samples of seed corn secured from 40 to 60 farmers in each of 29 counties in the state were planted side by side under identically the same conditions for a comparative study of quality and yielding power. These tests showed that in each of these counties there were from three to eight men who had corn yielding on average of 10.9 bushels per acre more than the average of all other local corns tested, an average of 19.7 bushels per acre more than seed purchased from seed firms, and an average of 13.5 bushels more than seed introduced into the county from prominent seed corn breeders or growers in other section of the state.

DO NOT DEPEND ON THE STATION FOR GERMINATION TESTS

During past years the Farm Crops section has tested over 12,000 different samples of corn for Iowa farmers. It will be remembered that the seed corn was very poor in 1910 and in that year alone over 4,000 samples were tested. The Farm Crops section has not offered to test samples this year. A general or composite test can be made so easily, and most farmers are now so familiar with methods of testing seed corn, that it has seemed unnecessary to do this.

Then again the germination tests reported by the College have, in some cases, been used to sell seed which was not of the same quality as the kernels sent to the College. We have no means of knowing that the seed sent us is representative of the bulk of the seed on the farm.

When a test is made by the College, the report is for the personal information of the farmer concerned and not to be used for advertising purposes.

See pages 8 to 12 for convenient methods of making germination tests.

THE COST OF TESTING SEED

The cost of testing individual ears of corn for germination will depend somewhat upon the method used and the efficiency of the operator. From the tests made at the experiment station the cost has been found to be from 15 cents to 45 cents for each 100 ears, this difference being due entirely to the method of testing which was employed. The cost when corn was tested by the Rag Doll method was 18 cents and by the saw-dust box method, 27 cents.

The cost of getting out enough seed for planting an acre will depend upon the method used and the quality of the corn. When the corn is of fair quality so that it is not necessary to throw away too many ears the cost per acre will be considerably

under 3 cents, while if the corn is of such poor vitality as to make it necessary to throw away 85% of the ears, the total cost of getting out enough seed for an acre will not be over 15 cents.

METHODS OF TESTING SEED CORN

There are two general methods of testing seed corn: the general or composite test and the individual ear test. While these two methods are very different there is a place for each.

Very few men in these days scoff at the idea of making germination tests of seed corn some time before planting. Many are familiar with the advantages of making individual ear tests. They have learned that it pays to know the quality of seeds. It is true that some seeds will sprout in the germinator which fail to make plants in the field, but it is certain that if they will not sprout in the germinator they will not grow in the field.

Many farmers are averse to making individual ear tests of seed corn, largely because of the more or less troublesome and cumbersome methods often employed, but all of the best farmers are coming to use the individual ear test whenever there is any doubt as to the quality of their seed corn. Before making individual ear tests it is always desirable to make a general or composite test in order to know, first, whether an individual ear test is necessary, and second, whether the corn is of sufficiently good quality to make an individual ear test worth while.

The simplest method of making a composite test is to take two kernels from each of 100 or more ears, mixing them together, and make a test of 100 or 200 kernels.

THE COMPOSITE TEST—THE DINNER PLATE METHOD

One of the very best methods of making a general or composite test of all kinds of seeds is that known as the "dinner plate" method. Fill an ordinary dinner plate level full of well moistened, but not wet, soil or sand. If sand can be had this is best. After taking 2 kernels from each of 100 ears, mix them together, and place them one at a time in the soil, pushing the tips of the kernels down until the whole kernel is imbedded. After the kernels are placed in the sand cover with another plate, which is inverted in order to prevent too rapid evaporation of the moisture.

If preferred, the kernels can be laid flat between two pieces of wet cloth (canton flannel is best). When this method is used the sand may be replaced by several layers of thoroughly wet cloth or paper.

THE RAG DOLL TESTER

A corn germination tester can be made on any farm at a cost of a few cents, which is as convenient and accurate to use as any tester which can be purchased.

During the years 1910 and 1911, 13 different methods of testing corn were compared from the standpoint of efficiency and convenience. Comparing home-made testers with those offered on the market, it can be said that the inexpensive home-made testers gave as accurate a test as the extensively advertised, manufactured articles which cost many times as much. Some of these home-made testers are very convenient to use; in fact they are more convenient than many of those which may be purchased.

The Rag Doll method of making individual ear tests has been used by the experiment station for the past several years, as these extensive tests have shown it to be the very best method available. A few of the advantages of the Rag Doll tester may be enumerated as follows:

1. It is the *cheapest tester* which can be made, including both labor and material.
2. It is *easy to make* — no muss or bother.
3. It is *quickly made*. Testers for 100 ears can be made in five minutes' time. These testers can be used over and over again.
4. It is *convenient to use*, equalling any tester made.
5. It *gives an accurate test* as is demonstrated by a large number of plantings made under field conditions.
6. It is adapted to either the "water method" or the "moist cloth contact method," as may be preferred by the operator.
7. It is *easily disinfected* for mold (boil clothes between each test).
8. It is *very compact* and can be moved from one place to another without difficulty.

To make a Rag Doll tester that will conveniently test 40 ears of corn take a strip of cloth 8 inches wide and 70 inches long and mark it lengthwise through the middle, preferably with a black wax crayon or a soft black pencil. Leaving 5 inches at each end of the cloth, mark lines crosswise, making the lines 3 inches apart. This will allow for 20 squares on each side, as shown in fig. 1. Mark the first square in the upper left-hand corner no 1, and the square in the upper right-hand corner no. 20; the lower left-hand corner no. 21 and the lower right-hand corner no. 40. It is also well to number every fifth square between as it makes it easier to locate the bad ears.

The ears having been arranged in regular order, with every ten ears separated by some convenient method, such as is shown in the illustration, remove 6 kernels from ear no. 1 and place in the square in the upper left-hand corner of the cloth, marked

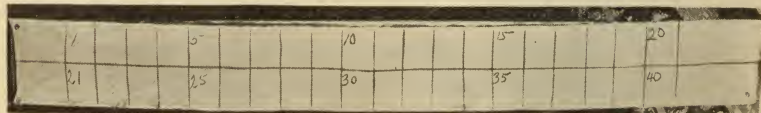


Fig. 1. The Rag Doll tester is simply a piece of cloth 8 inches wide and 70 inches long, marked off in squares.

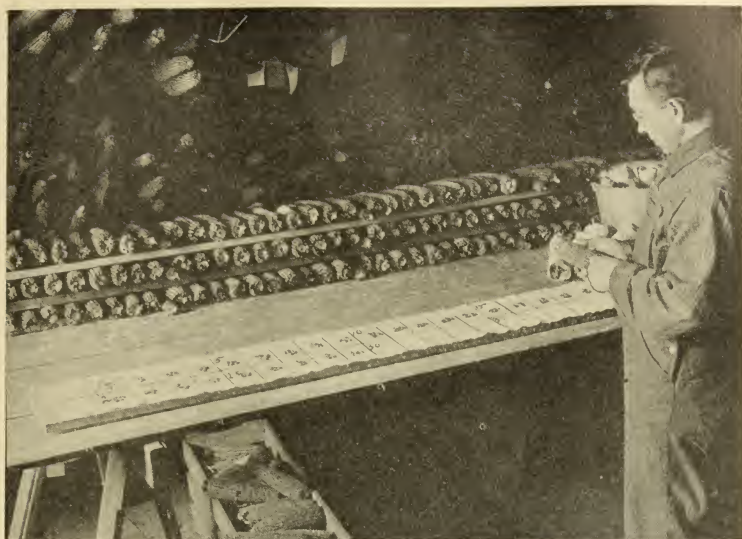


Fig. 2. Placing 6 kernels from each ear in the proper square of the moistened rag doll tester.

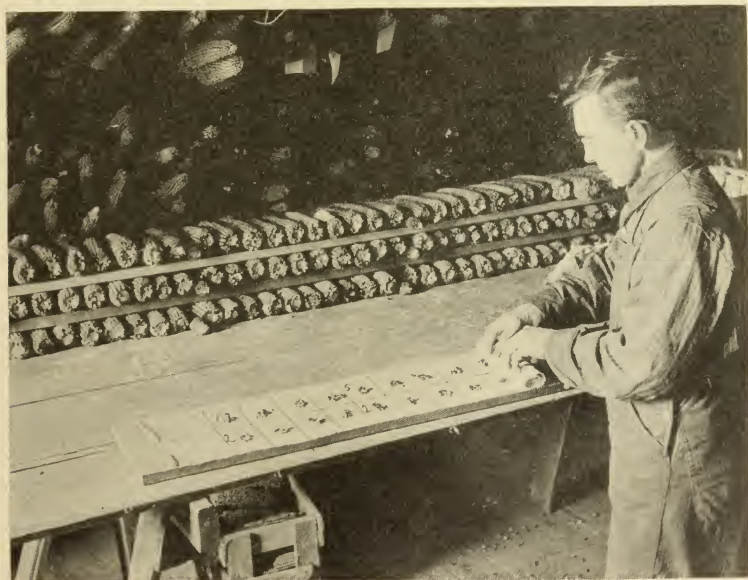


Fig. 3. Rolling up the Rag Doll tester after the squares have been filled with kernels, using a heavy piece of paper as a core. The cloth should be rolled loosely.



Fig. 4. A string is tied around the middle of the roll and then it is ready to be placed in water from 2 to 12 hours.

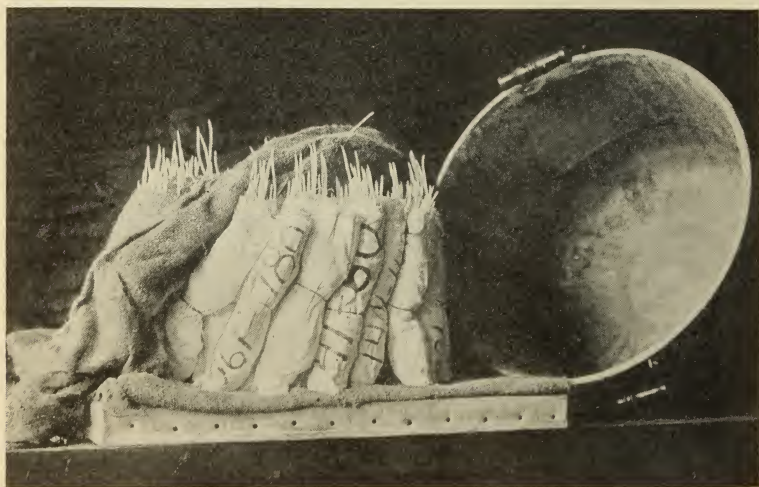


Fig. 5. A convenient way for germinating the kernels after they have been soaked is to stand them on end, spread wet burlap over them and then cover them with a bushel basket or pail.

no. 1. Take 6 kernels from ear no. 2 and place in the next square and so on until kernels have been removed from 40 ears.

When the cloth has been filled mark the numbers of the ears or their location on a tag or heavy paper, using this as a core around which to begin rolling the cloth. Since the cloth is moistened the kernels will not push out of place. It is important that the cloth be rolled rather loosely since the large number of kernels which the cloth contains will swell considerably and if the cloth is rolled too tightly they cannot germinate satisfactorily. When the rolling of the cloth is finished tie a string rather loosely around the middle, or use a rubber band. The roll can now be laid aside until the testing for the day has been finished, when they should be placed in a bucket of water where they may remain for from 2 to 12 hours, depending upon the preference of the operator. At the end of this time pour the water off, when the bucket may be turned upside down over the rolls, in this way keeping them from drying out while the kernels are given time to germinate. If the rolls are stood up the sprouts will grow towards one end of the roll and the roots towards the other, making the test much easier to read than where they are allowed to lie flat. This also insures better drainage and better ventilation. It is also well to put a wet piece of gunny sack or other coarse cloth around the rolls, especially if they do not fill the pail, bucket, or box which is used to cover them. In 5 or 6 days the germination should be ready to read.

READING THE TEST

Unroll on the testing board the last cloth filled, placing this in front of the ears which are represented. Examine all kernels carefully. In case that all six kernels do not show a strong germination the ear should be thrown away. If seed is very scarce, as in the present season, it may be well to save ears showing not more than 1 dead kernel out of the 6 tested. It would certainly be much better to use such seed as this, planting a little thicker than usual, than to risk buying seed, the adaptation of which is not definitely known.

SEED CORN INVESTIGATION AT AMES

During the past three years the farm crops section has had under way a rather extensive investigation on the care of seed corn, giving especial attention to the date of picking, the moisture content at date of picking, together with the conditions of storage, value of continuous artificial heat as compared with artificial heat while curing, or no artificial heat.

Several hundred ears of seed corn have been harvested at weekly intervals from the latter part of September until December. These ears have been divided into various lots of equal

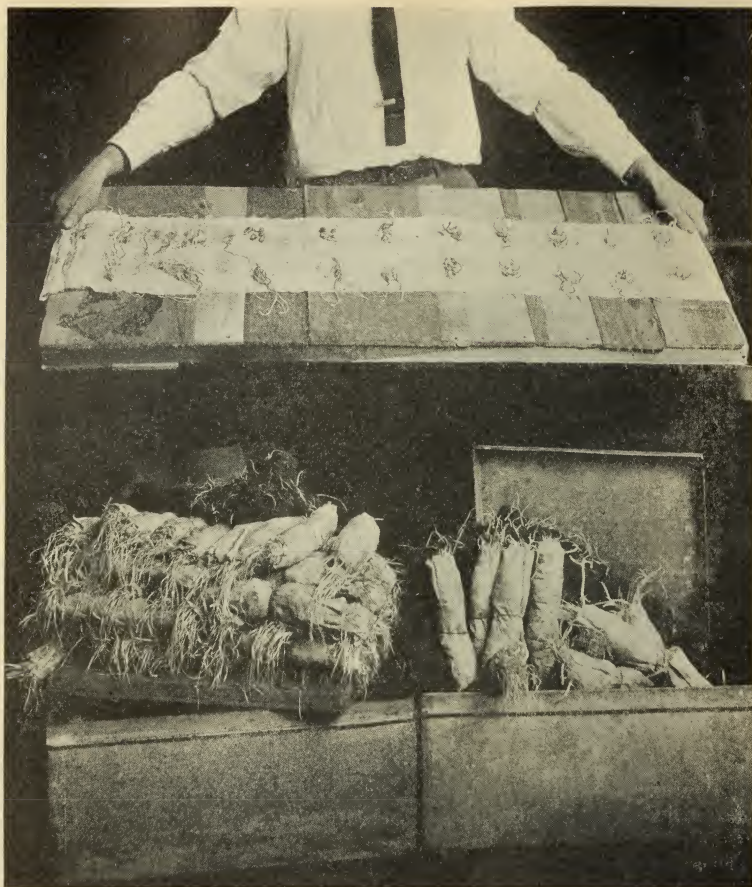


Fig. 6. If the rolls are laid flat, it is best to cord them up as shown in the lower part of this illustration, so that good ventilation may be insured.

value, each lot being cured or stored under different conditions.

During the fall of 1915, 220 lots of seed corn of 20 ears each were included in the test. The first lots were picked on October 4 and the last or eleventh lots on December 13. The field from which this seed was picked was of fairly good quality, though there were some ears throughout the field which were quite immature. Two selections were made each week, one of the most mature ears found, the other of immature or "soft" ears.

Each of the 4,400 ears was tested individually late in February. The results are so applicable to the seed situation this year that we deem it worth while to present a brief summary of some

of this data now. This must be considered only preliminary. The germination of some lots may change materially by the end of winter.

From the data presented in table IV we note that of the mature ears picked at weekly intervals throughout the fall and stored in seed houses with continuous heat, 74 per cent gave strong germination, the same quality of ears picked at the same time but stored in a closed shed with no artificial heat, 35 per cent, while that stored in an open shed showed only 11 per cent of strong ears. The more immature seed corn picked at weekly intervals and cured and stored in the seed house with artificial heat gave 54 per cent of strong ears, the closed shed 14 per cent, and the open shed 10 per cent.

TABLE IV. STORAGE CONDITIONS AS EFFECTING VITALITY

A table showing the average per cent of ears testing strong, weak, and dead when stored under different conditions.

Maturity of Seed Ears When Picked	Condition of Storage	No. of Different Lots Tested	Per Cent of Seed Ears Testing		
			Strong	Weak	Dead
Mature ...	Seed house, continuous heat..	11	74	13	13
	Closed shed, no heat.....	11	35	19	46
	Open shed, no heat.....	11	11	14	75
Immature	Seed house, continuous heat..	11	54	16	30
	Closed shed, no heat.....	11	14	11	75
	Open shed, no heat.....	11	10	8	82

Mature ears picked early in the season and given proper storage may be expected to give more than the 75 per cent of perfect ears shown in the above table. It must be understood that the test reported in the table includes eleven lots, some picked as late as December. Several of the early selections showed practically perfect germination when stored in the seed house and cured with artificial heat.

It must be granted that in some seasons when the fall is very dry and warm the conditions noted above in favor of curing the seed with artificial heat will not hold. In many seasons, however, it is well worth while to provide some artificial heat. This is particularly true with corn which contains considerable moisture when picked.

CURED WITH ARTIFICIAL HEAT VS. NO ARTIFICIAL HEAT

It will be noted from table V that mature seed which was artificially cured until January 1 contains 73 per cent of good ears, while the same quality of corn stored without artificial heat in a closed shed showed 35 per cent of such ears. In an open shed the per cent of strong ears was reduced to 11 per cent. With immature seed the difference in vitality is even more pro-

TABLE V. SHOWING THE INFLUENCE ON VITALITY OF THOROUGH DRYING IN THE FALL

Storage Conditions	Number Lots of Ears	Per Cent of Ears Testing Strong	
		Mature Ears	Immature Ears
In closed shed, artificial heat un- til January 1st.....	22	73	57
No artificial heat.....	22	35	14
In open shed, artificial heat un- til January 1st.....	22	76	55
No artificial heat.....	22	11	10

nounced, the seed in the closed and open sheds testing 57 and 55 per cent strong ears respectively when cured with artificial, while only 14 and 10 per cent of strong ears were secured when no artificial heat was used.

TESTING EACH EAR IN THE SPRING WILL NOT MAKE UP FOR NEGLECT IN THE FALL

When the general or composite test shows many dead kernels, the usual advice is to test separately the germination of each seed ear, as this makes it possible to separate out the best ears. While this is unquestionably the best possible thing which can be done under the condition, it cannot make up for carelessness and neglect in the fall. When the germination of seed has been seriously injured by freezing, or by any other cause, the stand in the field will seldom range above 75 per cent, even when nothing is planted but ears testing perfectly. This is due to the fact that with corn of this kind there are some dead kernels in nearly every ear even though the 6 tested all grow. Seed which is perfect in vitality, having been selected early and carefully stored, should give at least 95 per cent of a stand, other considerations being favorable. If, in making the individual ear test, it is found necessary to throw away 50 or 60 per cent of the corn, the planter should be set to plant a little thicker than usual in order to secure a normal stand.

IOWA AGRICULTURAL EXPERIMENT STATION
ENTOMOLOGICAL SECTION

WHITE GRUBS* IN IOWA

By R. L. Webster.

Much damage by white grubs occurred in northeastern Iowa in 1915. Corn and pastures were severely injured, although the damage was not so apparent last year as it was three years before. This was because of the excess amount of rain that kept vegetation green throughout the season in spite of the damage below ground.



Fig. 1.—A single White Grub
(From Britton.)

These grubs will be present in 1916, but will not cause damage except early in the season. Injury should not occur after the month of June. This is expected for the grub infested district in general. There may be exceptions in a few localities where the majority of the grubs are not of the same age.

Since the insects, as a rule, require three years in this latitude to complete their life cycle, damage may be expected every three years. The most injury is done by the grubs in their second year. General outbreaks have occurred in northeastern Iowa in 1912 and in 1915, and another may be expected in 1918. Figure 2 shows the area in which the crops were damaged in 1915. In some fields in 1915 the loss was practically 100 per cent.

The common May beetle or June bug is the parent form of the white grub. Most people are familiar with these insects, large, clumsy, black or brownish beetles that fly to lights in May and early June. Rising from the grass in which they hide during the daytime the beetles fly to the trees soon after sundown and feed there on the foliage throughout the night.

In 1914 in the grub district in northeastern Iowa thousands of acres of woodland were stripped of foliage late in May. Much of this timber was quite as bare as in winter, as indicated in fig. 3.

The abundance of these beetles in 1914 made it quite certain that the grubs would be common the following season. On this account articles were sent to the newspaper press early in 1915 giving warning of probable damage and urging farmers in this part of the state to take steps to avoid damage during that year.

The beetles deposit their spherical, white eggs in rather compact soil, preferring sod ground. These eggs hatch and the young grubs

**Lachnosterna* spp.

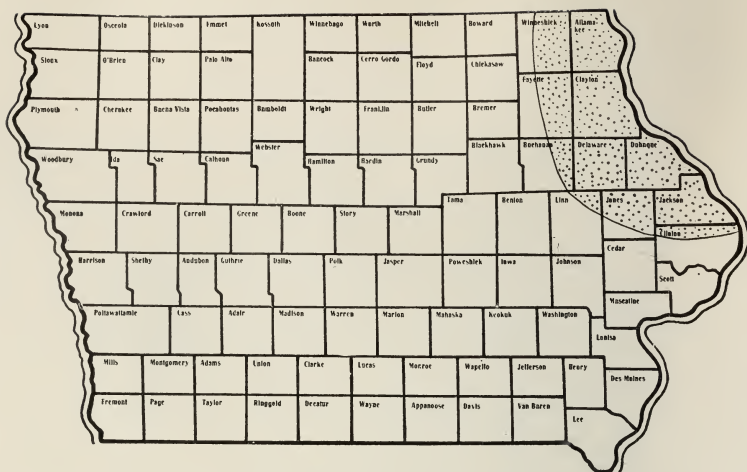


Fig. 2. Area where white grubs caused damage in 1915.

begin to feed that summer. Grubs hatching out one year do not become full grown for two years, and even then the insects remain in the soil for a third winter, emerging as beetles nearly three years after the eggs were deposited.

For all this we may have some grubs every year, since there are so many species of the insects, and these may mature in different years. It is fortunate that such is the case, for when a large number of beetles appear in one season, a serious outbreak of white grubs is practically certain the next year.

The Life Cycle.

A generalized life cycle of these insects is better shown as given herewith. Later investigations may show that some species have a different life history, but the cycle as given applies to Iowa conditions in general.

First Year. Beetles emerge from soil in May, feed, and deposit eggs. Grubs hatch and begin to feed, wintering over in the soil.

Second Year. Grubs feed during the season. The most damage to crops is caused in the second year. The grubs winter over in the soil, practically full grown.

Third Year. Grubs feed early in the season, pupate in June or July, changing to beetles a few weeks later, but the beetles stay in the soil over winter.

Fourth Year. Same as the first.

For northeastern Iowa the third year represents the general conditions for 1916.

CONTROL MEASURES

When the two year old grubs are in the fields damaging grass or corn, there is no practical measure we know of to get rid of them at once, without injuring the crop. However, measures may be taken to prevent further injury and to reduce the number of insects present in any particular field. Such steps are fall plowing, rotation, and turning hogs into grub infested fields.

Turning Hogs Into Infested Fields.

Hogs are very fond of eating white grubs and when turned into infested fields will clear them out in a short time, provided this is done before the grubs go deep in the soil in the fall.

In 1916 hogs may be turned into grub infested fields during May, before these fields are planted to corn. This will eliminate many of them. It should be done wherever possible.

One drawback to this measure must be mentioned. An intestinal worm of swine, the giant thorn-headed worm, passes one stage of its life in certain white grubs. Pigs eating grubs so infested take the parasite into their bodies. Through the pig's excrement the grubs are reinfested. It is apparent that both the pigs and the grubs must be present in any particular field in order that this worm may complete its transformations.

On the other hand, if young pigs, never before allowed to run out, are turned into a field that has had no pigs in it for the preceeding



Fig. 3. Timberland in Clayton county, Iowa, showing defoliation by May beetles. Photograph taken May 30, 1914. (Davis.)

three years, there can be no danger. The young pigs have had no chance to become infested and the grubs in three years time will have all matured or otherwise gotten out of the way, so they would be free from these worms.

Rotation.

Much may be done by an intelligent rotation, particularly where the grubs are abundant. Since the grubs are not known to infest such crops as clover, alfalfa or buckwheat, these may safely follow on sod ground in a "grub year". Small grains are attacked by the grubs, but to a less extent than corn or potatoes. When grubs are expected in any particular year, corn should never follow sod. Corn following corn, or some other cultivated crop is reasonably safe from serious grub injury.

By referring to the generalized life cycle one may determine when to expect the grubs. If the May beetles are exceptionally abundant one year, feeding on trees at night, or collecting at street lights or flying into houses, an abundance of grubs may be reasonably expected the next year. Again the grubs are likely to be abundant in three year intervals, in any given locality.

Fall Plowing.

Fall plowing is of much value in grub infested fields. This brings the grubs to the surface and crushes many of them. But the grubs go deeper into the soil for the winter, consequently plowing must be done before cold weather sets in. Early in October is the best time for this. Where the grubs are turned up in great numbers, it would be well to follow the plowing with a disc harrow, which would crush many larvae that might not be affected by the plow.

Fall plowing is especially important in 1916 in northeastern Iowa. This year the insects change to the beetles within their earthen cells and in such condition are more susceptible than common. Disturbing these cells means that the insects within will be destroyed. Fall plowing in 1916, preferably early in October is strongly advised for grub infested fields.

IOWA AGRICULTURAL EXPERIMENT STATION

DAIRY SECTION

Iowa Educational Market Milk Contest

By B. W. Hammer and A. J. Hauser.

According to the United States Department of Agriculture, the first milk and cream contest in this country was held at the National Dairy Show at Chicago in 1906. Since that time such contests have been held in conjunction with various dairy shows, fairs and other meetings, such as campaigns for the improvement of city milk supplies, in which milk producers and dealers were interested; up to February, 1915, 87 such contests had been judged by members of the Dairy division of the United States Department of Agriculture.

In general, it is believed that these contests have been of distinct service from an educational standpoint in teaching exhibitors the advantages or disadvantages of various methods of handling milk, altho it is recognized that commonly the attention given to the exhibited milk or cream is not given to the general supply.

The Dairy department of Iowa State college held its first educational market milk contest December 24, 1914, in connection with its annual short course. Previous studies had shown that much of the milk (both raw and pasteurized) sold in the state was not of the quality it should be and the contest was proposed as a means of stimulating its improvement.

The First Contest.

In the first contest two classes were recognized, a raw milk class and a pasteurized milk class, and a gold medal and a silver medal were offered in each; in the rules and regulations, however, there was a provision that an award would be withheld unless the score was at least 90. Each exhibit consisted of four one-quart bottles and was either produced or pasteurized two days before the scoring, so that dealers at a considerable distance from Ames would not be at any disadvantage. The samples were kept well iced while being held awaiting scoring. Both the raw and pasteurized milk was scored according to the United States Department of Agriculture score card. Six raw and four pasteurized exhibits were received. The results obtained are presented in table I, from which it will be seen that the total scores on the raw milk ranged from 59.75 to 96.00 and on the pasteurized milk from 87.75 to 96.50. The sample of raw milk that showed 1,500,000 bacteria per c.c. was shipped without ice, while the sample showing 184,000 per c.c. was taken from the regular output of one of the dealers. The sample submitted by exhibitor no. 6 is rather interesting in that it showed an acidity of .21% with a bacterial content of only 18,550 per c.c. The high acidity is accompanied by a high percentage of total solids; in our experience high total solids are likely to be accompanied by acidities over .20%.

The Second Series of Contests.

It then seemed desirable to hold a series of four contests extending over a period of one year and to award medals on the basis of the average of the three highest scores secured by each exhibitor. The averages of the three highest scores were used instead of the averages of four because it was recognized that it might be impossible for all dealers to exhibit in four contests and also because it seemed unde-

TABLE I—RESULTS SECURED ON MILK SCORED DECEMBER, 1914

Class	Exhibit- r's No.	Bacteria		Flavor		Fat		Solids not fat		Sedi- ment Score	Acidity		Pkg. Score	Total Score
		No. per c.c.	Score	Score	Score	Percent	Score	Percent	Score		Pct.	Score		
Raw	5	165	35.00	22.25	10.00	4.70	10.00	8.8	10.00	9.25	.14	5.00	4.50	96.00
"	1	165	35.00	21.00	10.00	5.90	10.00	10.0	10.00	8.75	.16	5.00	4.75	94.50
"	2	1,110	33.50	22.25	10.00	4.00	10.00	9.3	10.00	6.75	.16	5.00	4.75	92.25
"	6	18,550	27.00	22.50	10.00	5.90	10.00	10.7	10.00	9.50	.21	4.00	5.00	88.00
"	3	184,000	2.00	23.00	10.00	5.55	10.00	9.1	10.00	8.00	.17	5.00	4.50	62.50
"	4	1,500,000	0.00	21.00	10.00	4.00	10.00	9.5	10.00	9.25	.18	5.00	4.50	59.75
Past.	9	90	35.00	23.50	10.00	5.55	10.00	9.5	10.00	8.00	.18	5.00	5.00	96.50
"	10	2,050	33.00	23.50	10.00	4.55	10.00	9.4	10.00	9.50	.16	5.00	4.75	95.75
"	8	1,100	33.50	22.25	10.00	4.30	10.00	9.4	10.00	9.25	.15	5.00	4.50	94.50
"	7	13,600	28.00	21.25	10.00	4.55	10.00	9.6	10.00	9.00	.15	5.00	4.50	87.75

TABLE II—RESULTS SECURED ON MILK SCORED MARCH 1915.

Raw	2	785	34.00	23.50	10.00	5.00	10.00	9.7	10.00	8.75	.17	5.00	4.50	95.75
"	3	600	34.50	22.50	10.00	5.20	10.00	9.7	10.00	9.00	.19	5.00	4.50	95.50
"	6	95	35.00	21.75	10.00	7.80	10.00	9.0	10.00	8.50	.17	5.00	4.75	95.00
"	1	150	35.00	22.50	10.00	3.50	9.00	9.2	10.00	8.75	.17	5.00	4.50	94.75
"	7	555	34.50	22.00	10.00	5.60	10.00	8.6	9.00	8.25	.13	5.00	4.75	93.50
"	9	75	35.00	22.50	10.00	3.70	9.40	8.3	6.00	9.25	.15	5.00	4.50	91.65
"	4	1,490	33.50	22.25	10.00	3.80	9.60	8.4	7.00	8.00	.14	5.00	4.75	90.10
"	8	111,000	9.00	22.50	10.00	3.80	9.60	8.4	7.00	9.00	.15	5.00	4.75	86.85
"	5	1,000,000	00.00	20.50	10.00	4.20	10.00	8.5	8.00	8.75	.16	5.00	4.75	87.00
Past.	12	30	35.00	22.50	10.00	4.10	10.00	8.7	10.00	8.50	.14	5.00	5.00	96.00
"	11	615	31.50	22.75	10.00	3.60	9.20	8.4	7.00	9.00	.13	5.00	5.00	89.45
"	10	240,000	00.00	22.50	10.00	3.80	9.60	8.4	7.00	7.75	.14	5.00	4.50	86.36

TABLE III—RESULTS SECURED ON MILK SCORED JUNE, 1915.

Raw	9	80	35.00	22.00	10.00	4.30	10.00	8.7	10.00	8.75	.14	5.00	4.50	95.25
"	3	5,000	32.00	22.50	10.00	6.30	10.00	8.9	10.00	9.50	.16	5.00	4.50	93.50
"	13	565	34.50	21.25	10.00	4.60	10.00	8.5	8.00	8.75	.15	5.00	4.50	92.00
"	2	13,800	28.00	23.50	10.00	6.85	10.00	9.0	10.00	8.50	.16	5.00	4.50	89.50
"	6	20	35.00	21.00	10.00	2.60	0.00	9.5	10.00	9.25	.15	5.00	4.75	85.00
"	14	700,000	00.00	20.00	10.00	3.85	9.60	9.0	10.00	8.75	.17	5.00	4.50	87.85
"	16	310	35.00	22.25	10.00	4.70	10.00	8.7	10.00	8.25	.14	5.00	5.00	95.50
Past.	15	13,800	28.00	21.50	10.00	3.80	9.60	9.0	10.00	8.00	.14	5.00	4.50	86.60
"	11	54,000	20.00	23.25	10.00	3.80	9.60	8.4	7.00	8.25	.15	5.00	5.00	87.10
"	12	60,000	19.00	21.25	10.00	14.00	10.00	8.1	4.00	8.50	.13	5.00	4.75	72.50

TABLE IV—RESULTS SECURED ON MILK SCORED SEPTEMBER, 1915.

Raw	22	540	34.50	22.75	3.70	9.40	9.0	10.00	9.75	.16	5.00	5.00	96.40
"	19	270	35.00	21.75	4.40	10.00	9.1	10.00	8.75	.15	5.00	5.00	95.50
"	6	110	35.00	21.50	4.00	10.00	9.4	10.00	8.75		4.75	4.75	95.00
"	17	65	35.00	21.75	4.65	10.00	8.9	10.00	8.25	.16	5.00	4.75	94.75
"	18	1,195	33.50	21.25	5.05	10.00	9.4	10.00	8.75	.16	5.00	4.75	93.25
"	9	85	35.00	22.50	4.55	10.00	8.4	7.00	8.50	.17	5.00	4.50	92.50
"	3	25,500	25.00	22.25	5.80	10.00	10.1	10.00	8.75	.18	5.00	4.50	85.50
"	21	33,500	24.00	21.25	5.75	10.00	9.4	10.00	8.75	.15	5.00	4.75	83.75
"	20	12,500	28.00	22.25	2.95	0.00	8.8	10.00	8.50	.17	5.00	4.50	78.25
"	14	89,000	13.00	22.50	3.90	9.80	9.1	10.00	8.50	.15	5.00	4.75	73.55
Past.	16	340	35.00	23.25	5.00	10.00	9.3	10.00	8.75	.18	5.00	5.00	97.00
"	12	10	35.00	23.00	3.40	8.00	9.5	10.00	8.75	.17	5.00	5.00	94.75
"	23	2,470	33.00	23.00	3.35	7.00	8.6	9.00	9.00	.15	5.00	4.50	90.50

TABLE V—RESULTS SECURED ON MILK SCORED JANUARY, 1916.

Raw	6	20	35.00	22.00	4.00	10.00	9.4	10.00	9.50	.16	5.00	4.75	96.25
"	9	65	35.00	22.00	3.85	9.60	8.9	10.00	9.50	.17	5.00	4.50	95.60
"	8	1,510	33.50	22.25	5.40	10.00	9.5	10.00	8.25	.19	5.00	4.75	93.75
Past.	16	390	35.00	24.00	6.05	10.00	9.8	10.00	7.50	.19	5.00	5.00	96.50
"	12	70	35.00	23.50	5.70	10.00	9.5	10.00	8.25	.21	4.00	5.00	95.75

sirable to practically eliminate an exhibitor if one low score was secured. Instead of requiring four one-quart bottles in each exhibit, it seemed best to require only two. In this series the Iowa Dairy and Food commission co-operated by supplying one of the judges. The educational feature was emphasized in that criticisms were offered where it was felt that they would be of any benefit to the exhibitor.

On March 24, 1915, 9 raw and 3 pasteurized samples were received; on June 21, 1915, 6 raw and 4 pasteurized; on September 22, 1915, 10 raw and 3 pasteurized, and on January 27, 1916, 3 raw and 2 pasteurized. The small number of samples secured on January 27, 1916, was undoubtedly due to the fact that a number of the former exhibitors felt that there was little chance of their securing an average above 90. Tables II, III, IV and V present the results obtained on the milk scored in March, June, September and January, respectively, while the averages of the three highest scores of the dealers submitting at least three samples are presented in table VI.

TABLE VI—AVERAGES OF THREE HIGHEST SCORES OBTAINED BY EACH EXHIBITOR.

Pasteurized Milk Class.	
Exhibitor's Number	Average Score
16	96.33
12	95.50
Raw Milk Class.	
6	95.41
9	94.45
3	91.50

Results of Second Contest.

The total scores on the raw samples received in March varied from 57.00 to 95.75, while on the pasteurized they varied from 56.35 to 96.00. A sample of raw milk with an acidity of .19% and a bacterial content of only 600 per c.c. was encountered; the sample also showed a high content of solids.

The raw samples scored in June showed total scores of from 57.85 to 95.25, and the pasteurized samples total scores of from 72.50 to 95.50. A sample of pasteurized milk showing a fat content of 14.00% and a content of solids not fat of 8.1% was received.

In September the total scores on the raw samples varied from 73.55 to 96.40 and on the pasteurized samples from 90.50 to 97.00. Of the thirteen samples submitted, six scored perfect on bacteria.

In January the raw samples showed total scores of from 93.75 to 96.25 and the pasteurized samples total scores of from 95.75 to 96.50. At this scoring four out of five samples scored perfect on bacteria. One of the pasteurized samples showed an acidity of .21% and a bacterial content of 70. It seems improbable that the high acidity was due to bacteria which were destroyed during pasteurization, since the flavor was very satisfactory. There was a high content of solids, but not as high as in another of the samples showing an acidity of .19%.

Five of the exhibitors submitted three samples; the average scores secured in the pasteurized milk class were 96.33 and 95.50, while in the raw milk class they were 95.41, 94.45 and 91.50.

From the scores secured, it is evident that there has been an improvement in the quality of the milk submitted. While this does not imply an improvement in the quality of the milk sold in the state, it justifies the assumption that the contests are of educational value and that eventually a better general milk supply may be hoped for. The Dairy department of the Iowa State college plans to continue the educational market milk contests, and to offer criticisms where it is believed that these will be of aid to the producer or dealer.



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